ROYAL NAVY HANDBOOKS

EDITED BY

COMMANDER CHARLES NAPIER ROBINSON, R.N.

TORPEDOES

AND

TORPEDO-VESSELS

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A DESTROYER AT WORK. [Fronti

TORPEDOES

AND

TORPEDO-VESSELS

BY

George Elliot

LIEUT. G. E. ARMSTRONG

LATE R.N.

ILLUSTRATED WITH A FRONTISPIECE BY

CHEVALIER E. DE MARTINO

AND NUMEROUS PHOTOGRAPHS AND DIAGRAMS

LONDON

GEORGE BELL AND SONS

1896

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TO MY OLD FRIENDS AND SHIPMATES

IN THE NAVY,

WITHOUT WHOSE KINDLY ENCOURAGEMENT

AND ASSISTANCE

THE WRITING OF THIS VOLUME

WOULD HAVE BEEN LABOUR IN VAIN

PREFACE

THE primary object of the author in compiling this little handbook has been to convey to the mind of the general reader an elementary knowledge of the most modern development of naval warfare, namely, the science of torpedoes. All the books which have been written on the subject hitherto are of so detailed and technical a nature that the ordinary "man in the street" has been entirely precluded from learning its intricacies. As a consequence, submarine warfare has been invested by the public with an element of mystery which should not properly belong to it. There is no reason whatever why the average Englishman should not be as well versed in mines, torpedoes, and torpedo vessels as in any other branch of naval science. It is well, too, that our countrymen should possess some real knowledge of the subject, for the next great naval war will bestow upon the torpedo and its users a halo of romance which will eclipse entirely that surrounding the gun and the ram. Perhaps its greatest claim to recognition on our part is the fact that it is a weapon which will nearly always be wielded by the younger officers of the service. None

know better than they that the torpedo service in war time will be the shortest ladder by which they can mount the pinnacle of fame, and we may trust them to take advantage of that knowledge to the full.

In spite of the enormous importance of torpedoes and torpedo vessels, very few people know anything whatever about them. Even the average educated landsman has only the vaguest idea of the appearance or power of a Whitehead torpedo; and, judging by the queries frequently addressed to naval officers on the subject by their friends on shore, there is considerable doubt in the minds of the latter as to whether a torpedo boat travels beneath the surface of the water or is a torpedo in itself! That a nation like ours, which owes its very existence to the efficiency of its Navy, should be so ignorant regarding one of the chief weapons of that Navy, is bad for the country and bad for the service. Fortunately, however, owing to the increased interest in naval matters which has arisen during the past few years, there has come into existence a large body of English readers, who have proved themselves only too glad and ready to make themselves acquainted with the doings of their country's Navy whenever any attempt is made to teach them. So far as the science of torpedoes is concerned, they have had little opportunity of obtaining that knowledge as yet, and if this little volume is able to supply the deficiency, even to a modest extent, the purpose for which it has been written will have been realised.

In the compilation of this book much valuable assistance has been received from officers and constructors. The part dealing with torpedoes and mines

has been corrected by officers who, on account of their special study and knowledge of the subject, may be considered as experts in the science of torpedo warfare, and their revision will, it is hoped, give an authority to the book which would otherwise have been quite undeserved. In the part dealing with torpedo vessels, most generous assistance has been given by the different firms to whom the construction of our torpedo flotilla has been entrusted; and most particularly does the author tender his thanks to Messrs. Thornycroft and Messrs. Yarrow, the well-known torpedo boat builders; to Sir William Armstrong, Mitchell, and Co., of Elswick; and to Messrs. Maudslay, Sons, and Field, who have constructed engines for many of our "catchers."

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ILLUSTRATIONS

ERRATA.

Page 22, line 18. *For* "on the opposite page" *read* "opposite page 69."

Page 154, line 3. *For* "armoured" *read* "armed."

Page 232, line 4. *For* "two with Reed boilers, and one with Du Temple boilers" *read* "three with Reed boilers."

The *Janus* described on page 251 as being fitted with Du Temple boilers is fitted with Reed boilers.

The illustration opposite page 48 is from a photograph by Messrs. C. West and Son, Southsea.

in the art of naval warfare.

The science of torpedoes may be divided into two branches—namely, the active torpedo proper, and the

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passive mine. The torpedo has to be guided or aim by human agency in doing its work, whilst the mine dc its work alone, after being carefully prepared and left look after itself. Or at least that is the case with the mines known as "contact" and "mechanical"; the on known as "observation" have to be fired at the critic moment by an operator at a distance. Both torpedo and mines first came into existence during the progress the American War of Secession, when no fewer th twenty-eight vessels were blown up by mines and six vess by various forms of torpedoes. All these weapons we of the most crude and make-shift description, yet th served the double purpose of doing what was required them and of giving their users the first useful insight in what was fated to be a highly important branch of warfa in the future. Curiously enough, in spite of the enormo benefits which torpedoes gave to their users on th occasion, they received only the scantiest attention aft the conclusion of the war. Yet their remarkable succe set a good many clever heads thinking, and it was i 1864, or only two years after, that the original idea the Whitehead torpedo was evolved from the brain an officer in the Austrian Navy. Since then th number of patterns of different torpedoes invented hav been almost innumerable. Rocket, drifting, spar, towin dirigible, auto-mobile, and locomotive torpedoes have a in turn been tried and adopted; but in the English Navy at least, only three forms are retained, namely spa auto-mobile, and locomotive. The spar torpedo is th simplest form of all, and is at the same time the mos dangerous to the user. The auto-mobile is represented b the Whitehead, and the locomotive by the Brennan.

But though the torpedo has advanced in improvemen immensely, the mine has stood, at least until the past fe

years, comparatively still. This is perhaps accounted for by the fact that the former presents far more opportunities for ingenuity than the latter. Much has been done however in the way of increased certainty of action, and greater simplicity of construction and firing. The great advances made too in the science of electricity have resulted in improved cables and batteries, and better forms of fuses and circuit closers. Still the great desideratum in efficient mining is not so much perfection in construction as absolute secrecy in the plan of laying. Mines which are laid down in a waterway are so many dangers to navigation, and if their actual position is known to the enemy, they may, to a certain extent at least, be avoided. But if the plan of their positions is kept secret they constitute a far more efficient protection to a harbour than any amount of forts and guns. They are essentially weapons of defence instead of offence, and therein lies their chief difference from torpedoes. An opposing fleet might easily bring itself to attack a flotilla of torpedo vessels, but it would hesitate very considerably before risking its vitals over a mine-field. The Japanese fleet at the Yalu, for instance, did not hesitate to attack their enemy in the open sea, but they took very good care not to venture on an exploring expedition up the river after the vessels there, for the excellent reason that there were more formidable obstacles than guns to prevent their doing so. The only way in fact to overcome the passive resistance of a mine-field is to destroy it or render it useless; and, as will be explained later on, there are various ways of doing this, though, as may be imagined, if the field is protected by forts or ships, the operation of clearing it away is extremely hazardous. Perhaps the most overwhelming evidence ever yet presented of the moral power of submarine mines was given during the course of the

Franco-Prussian War, when the French fleet were prevented from entering Prussian harbours simply through fear of submarine dangers. It is true that important occasions have arisen when the moral power of a mine-field has been successfully defied by a brave and desperate invader. For instance, Captain Mahan in his interesting biography of Admiral Farragut tells us how a combination of desperate circumstances forced that gallant officer to take his fleet through a channel which was known to be "alive" with mines. Already one of his ships, the *Tecumseh*, had been struck by one of them, which sent her to the bottom immediately, and for all he knew the same fate awaited the rest of his fleet should they presume to steer into the fatal patch of water. Under less imperative circumstances it may be taken for certain that the admiral would have given the mine-field a wide berth after this disaster. As it happened, however, he was literally between the devil and the deep sea. Owing to the bad manœuvring of his leading ships the fleet had been thrown into a state of confusion, and prompt action alone could save them all from destruction. "To advance or to recede seemed alike dangerous. Ahead lay the dreaded line of torpedoes; behind was the possibility of retreat, but beaten, baffled, and disastrous." At the supreme moment the admiral chose the former alternative. In doing so he demonstrated his wisdom and his pluck. The odds were desperately against him; still there was just a chance that the mines were defective or not so numerous as he feared. "I cannot lose all," thought the admiral; "I will attack, regardless of consequences, and never turn back." He played the right card, for as the fleet passed over the mine-field "the cases of the torpedoes were heard by many on board knocking against the copper of the bottom, and many of the primers snapped audibly, but no torpedo exploded."

Had the mines been in a state of proper efficiency, Admiral Farragut and his fleet would have gone to the bottom of the harbour, and instead of gaining a victory they would have suffered thorough and overwhelming defeat. Although the admiral successfully defied the mine-field, probably no man has ever yet lived who has so thoroughly experienced the moral power of one.

As has already been pointed out, there is no half measure about a mine, and any ship, however well fitted she might be to stand an amount of pounding from forts and ships, would be utterly overcome if a charge of gun-cotton exploded under her bottom. In the next naval war therefore mines are likely to have more moral than practical effect, and numbers of harbours will remain unmolested by the enemy without their defenders having occasion to fire a single charge.

The adoption of the torpedo as a naval weapon has had one especial and beneficial effect on the sea service of the present day. It has been the means of supplying the younger officers of the navy with a fresh outlet for display of dash and enterprise. Twenty years ago there was every prospect that the introduction of mastless ships would turn the life of an ordinary junior executive officer into the most uneventful and humdrum of existences. It looked as if watch-keeping and deck drills were to be the sum total of his career in peace time, unless he was fortunate enough to obtain the independent command of a small gunboat, and even in that case he would hardly be better off than he was before. The advent of the torpedo and the new classes of vessel which followed in its wake have changed all that however. With a flotilla of torpedo boats and a host of "catchers" and "destroyers" there stand to hand so many opportunities of displaying individual ability, and in war time so many roads to fame and

honour. In battle the greatest prizes may fall to the hands of the youngest officers. Can any one, for instance, conceive a greater feeling of victory and exultation than that which would arise in the heart of an officer who, having successfully delivered a torpedo into the side of the enemy, sees the great ship bowing down before him shattered and overcome, the victim of his skill and daring. One minute of a man's life under such circumstances is worth all the other years together. In a word, the torpedo has brought into the navy a fresh zest, a new romance, and possibilities more brilliant than were ever existent before its adoption.

CHAPTER II

THE WHITEHEAD TORPEDO

If the ordinary man in the street were asked what he considered the most wonderful machine ever invented, he would probably reply that it was either the loom or the steam-engine. And he would be right, too, if by the word "wonderful" was meant that which had the most far-reaching results on mankind.

But if he simply based his choice on that machine which was the outcome of the highest mechanical ingenuity and perfection of construction, the only correct answer which he could possibly give would be—the Whitehead torpedo. Yet how few people know anything whatever of the construction of this wonderful machine, or indeed have ever even seen it. In the navy itself its mysteries and intricacies are of such a nature as to prevent any but the "specialists" possessing more than a rudimentary knowledge of its working and construction. And this is not surprising, for officers who have made a special study of torpedoes for years will tell you that there is always something to be learnt and discovered regarding Whiteheads. As the physician is continually improving his knowledge of the inner working of five odd feet of human bone and tissue, so the torpedo officer is always finding out some new trait

or eccentricity in the steel "babies," as he affectionately styles them, which are placed in his charge. This comparison appears all the more true when it is remembered that each torpedo has its own idiosyncrasies, which have to be carefully studied and corrected continually if it is to be trusted to perform its duty properly when the time comes for it to start on its one and final errand of destruction, and give its puny life for the life of a ship. And if that mission is faithfully performed, then indeed will the constant care and attention bestowed on it during its lifetime be amply rewarded, for the ship which receives a blow from a Whitehead torpedo is doomed as surely as if she was already at the bottom of the ocean. The arts of shipbuilders and steel-workers stand for nothing when a Whitehead torpedo succeeds in striking a ship's bottom and tears and rends it with the explosion of 200 lbs. of guncotton. In the hands of ignorant or careless people, the Whitehead is nearly as dangerous to its friends as it is to its foes, but in the hands of skilful and resolute men, it is the most terrible engine of warfare which the world has ever seen.

The origin of the Whitehead torpedo was due to the enterprise of a Captain Lupuis of the Austrian navy, who carried out a series of experiments entirely on his own initiative with a view to discovering a means of propelling a small fireship or floating torpedo along the surface of the water, and directing it from a fixed base by means of ropes and guiding lines. His idea was to charge the forward end of the little fireship with gunpowder, or some other explosive, and, on its coming in contact with the ship aimed at, to explode the charge by automatically firing a pistol. The motive power of the torpedo was to be derived either from steam or clockwork, preferably the latter. After various experiments in this direction he laid his ideas and

suggestions before his Government, and he was informed that in the opinion of the naval authorities the suggestion was unworkable unless he could discover some really reliable form of independent motor, and a better means of steering the fireship. Nothing daunted, Captain Lupuis set to work again to solve the riddle, and at last, one day in 1864, a fortunate impulse prompted him to enlist the help and advice of a thoroughly good working mechanic. At that time Mr. Whitehead was filling the post of manager to an engine manufacturing company at Fiume, and Captain Lupuis, having heard of his reputation for mechanical skill, determined upon seeking his advice and assistance. The officer's crude ideas, though unworkable in themselves, were nevertheless the means of attracting the attention of Mr. Whitehead to what promised to be a remarkably good field for mechanical ingenuity and enterprise, and from the day when construction of locomotive torpedoes was first suggested to him, he has made the designing and construction of them a work peculiarly his own.

It was not long before Mr. Whitehead discovered that a locomotive torpedo which travelled on the surface of the water and was guided from a ship or the shore by ropes was eminently unpractical, or at any rate that such a machine would only possess a very limited sphere of usefulness. Accordingly he abandoned Captain Lupuis's plans, and set about himself to discover whether it was not possible to devise a torpedo which would be entirely independent of outside aid when once it had been started on its course, and which possessed the additional advantage of running beneath the surface of the water. The problem was a terribly difficult one to solve, but after two years of hard work and anxious consideration he managed to construct his first torpedo of the type which was for ever afterwards to be associated with his own name. His only assistants in this

work were his own son, a mere boy, and a skilful and trusty workman. No one else was allowed to have the slightest glimpse of the mysterious machine during the time it was under construction, and consequently the surprise of the outside world was all the greater when at last it emerged from its hiding-place in a completed form.

This first Whitehead torpedo was of a very different shape indeed to those of the present day. It was built of steel, was 14 inches in diameter, 16 inches at the fins, and weighed 300 pounds. Its explosive charge was 18 pounds of dynamite. The motive power was compressed air charged to a pressure of about 700 pounds to the square inch, and the air-chamber was made of ordinary boiler plate. The speed of the torpedo when running under favourable circumstances was but six knots, and that only for short distances. As has been pointed out, the torpedo, although a marvel of ingenuity, was on the other hand exceedingly erratic in its performances. In one important particular it continually failed, and that was in the regularity with which it kept its proper depth in the water. At times it would run skimming along the surface, whilst at others it dived down to the depths and explored the bottom. Not, by the way, that the torpedoes of the present day do not sometimes do the same, but still it is the exception and not the rule, and whenever they indulge in such vagaries they are at once examined and readjusted.

Although, as has been pointed out, the original Whitehead was far from being an ideal locomotive torpedo, yet it showed such marvellous promise of further improvement, and was so vastly superior to any other form of torpedo yet devised, that the Austrian Government decided to enter upon a series of experiments with a view to discovering what its possibilities really were. Accordingly they gave orders for a committee of officers and engineers to fit up

a submerged tube on board one of the gunboats and make a report thereon.) At the end of six months of exhaustive trial, the committee reported that Mr. Whitehead's invention was unquestionably a valuable one, and that its adoption in the Austrian navy should take place as soon as possible. Whilst these experiments were going on, Mr. Whitehead had been thinking out a means of controlling the torpedo to a uniform depth, for its failure in this respect was undoubtedly its weakest point. By 1868 this further riddle had been solved by the adoption of what is known as the "balance chamber." This part of the torpedo's anatomy was always kept a profound secret until four or five years ago, except to those officers who went through the special course of Whitehead instruction. The pains taken to preserve this secret were as elaborate as they were futile. The room where the great mystery was unravelled was closed with locked doors, with sentries on guard outside, and every porthole and window carefully screened or closed. The secret, however, was too commercially and strategically valuable to be kept for long, and a few years ago the authorities having discovered that it was known to every civilised power in Europe, impressed upon Mr. Whitehead the futility of any further mystery. The general working of the balance chamber will be explained later on, and it will be seen that although a model of ingenuity and delicate workmanship, the principle of its construction is, like most clever inventions, simple in the extreme.

Although the Austrian Government fully acknowledged the value of Mr. Whitehead's invention by adopting it for use in their own navy, they were precluded by financial reasons from securing its exclusive purchase for themselves. Accordingly the inventor entered into negotiations with other Powers, and offered for their trial and

purchase a type of torpedo containing further improvements still. Amongst other things the air chamber was made of one piece of steel capable of withstanding a pressure of eighty atmospheres, which gave the torpedo a speed of eleven knots for a minimum distance of two thousand feet. So impressed were the English Admiralty by what they had heard concerning the trials in Austria, that they instructed the Commander-in-chief in the Mediterranean to appoint a committee of officers from his fleet to inquire into the matter and ascertain whether Mr. Whitehead's wares were all that he described them to be. Apparently the committee were very favourably impressed, for the following year the Admiralty requested that gentleman to convey to England two torpedoes and a submerged tube for the purpose of carrying out exhaustive trials and experiments.

Acting on these instructions, Mr. Whitehead brought over the first two English torpedoes. They were of two sizes and of the following dimensions:—

	Length. ft. in.	Max. Diam in.	Charge.
Large Torpedo	14 0	16	67 lb. Guncotton.
Small Torpedo	13 10½	14	18 lb. Dynamite.

Although differing slightly in measurement, the two torpedoes were constructed on practically similar lines, the engines being the same in every particular, though the mode of firing and packing the heads was different. In two important particulars these torpedoes differed from those of the present day. Firstly, they carried a projecting vertical fin both above and below, and running the whole length of the torpedo; and, secondly, they only carried one screw, instead of two revolving in opposite directions. Both were made of steel, and the air-chamber

of each was tested to the same pressure though differing slightly in size.

The trials were carried out on board the *Oberon*, an old paddle-wheel sloop, and the torpedoes were fired from a submerged tube fixed in her bows, and ejected by an impulse rod driven forward by compressed air. In order that the capabilities of the torpedo should be tested in every direction, an apparatus was devised for discharging it from a boat or launch, and as many runs were made by this means as with the submerged tube. It is curious that the mode of launching now in most common use, namely, from a tube above water, was not adopted or indeed even tried until some years later; still for all that, the trials with the submerged tube and boat apparatus on board the old *Oberon* showed quite clearly enough the wonderful capabilities of the new weapon. Over one hundred runs were made during these trials, and the average speed obtained was from 8·5 knots for a distance of 200 yards, and 7·5 knots for a distance of 600 yards. The adoption of the balance chamber showed that the difficulty of keeping a regular depth during the run was almost entirely overcome, although the torpedoes still continued to be rather erratic and uncertain in this respect. At the conclusion of these trials the committee sent to the Admiralty a report of their results and deductions. They affirmed, in the first place, that the vessel which was stationary might be fired at end on, with every probability of striking, at a distance of 200 yards; that a ship at anchor might be struck broadside on at any distance up to 400 yards; but that a ship under way, and going at a moderate rate of speed, could be struck with a fair degree of certainty up to 200 yards. Judging by the capabilities of the present-day type of Whitehead, such a verdict as that given by the committee seems to

afford scant praise. Nevertheless the performances of the torpedo at that time eclipsed anything which had ever been seen before in that direction, and the committee were naturally impressed with the wonderful ingenuity and delicate construction of the machine.

After these trials had been completed, experiments were carried out for the purpose of learning the destructive properties of a torpedo if fired against a ship protected with a crinoline of nets. The old wooden corvette *Aigle* was selected for the ordeal. Anchored in the Medway, and surrounded with thick nets 80 feet long by 12 feet deep, suspended 15 feet from the ship's side, a large-sized torpedo was then fired at her from the *Oberon* at a distance of 136 yards from the net. This first shot, curiously enough, proved in a very forcible manner that the destructive powers of the torpedo were as great as its running was erratic. Although the target was perfectly stationary, the torpedo managed to pass just outside the edge of the net and strike the ship under the quarter, with the result that the explosion tore a hole in her bottom 20 feet long by 10 feet deep, the centre of the hole being about 10 feet from the surface of the water. As might be expected, the ship sank down on to the mud immediately. Another torpedo was then fired, and this time with more desired results, the explosion taking place on the nose of the torpedo striking the net, the ship not being hurt in any way whatever.

As a result of all these trials and experiments, the committee of investigation finally reported that in their opinion "any maritime nation failing to provide itself with submarine locomotive torpedoes' would be neglecting a great source of power both for offence and defence." This decisive verdict was followed by equally decisive action on the part of the Admiralty. In spite of the protests and sneers of the old gunnery school of officers, the English

Government showed their thorough agreement with the recommendations of the committee by purchasing the secret and right of manufacture of the Whitehead torpedo for £15,000.

This recognition on the part of the first maritime Power in the world of the merits of the locomotive torpedo had the inevitable result. France, Italy, and Germany quickly followed our example, and at the present day every navy of importance, is using the Whitehead torpedo.

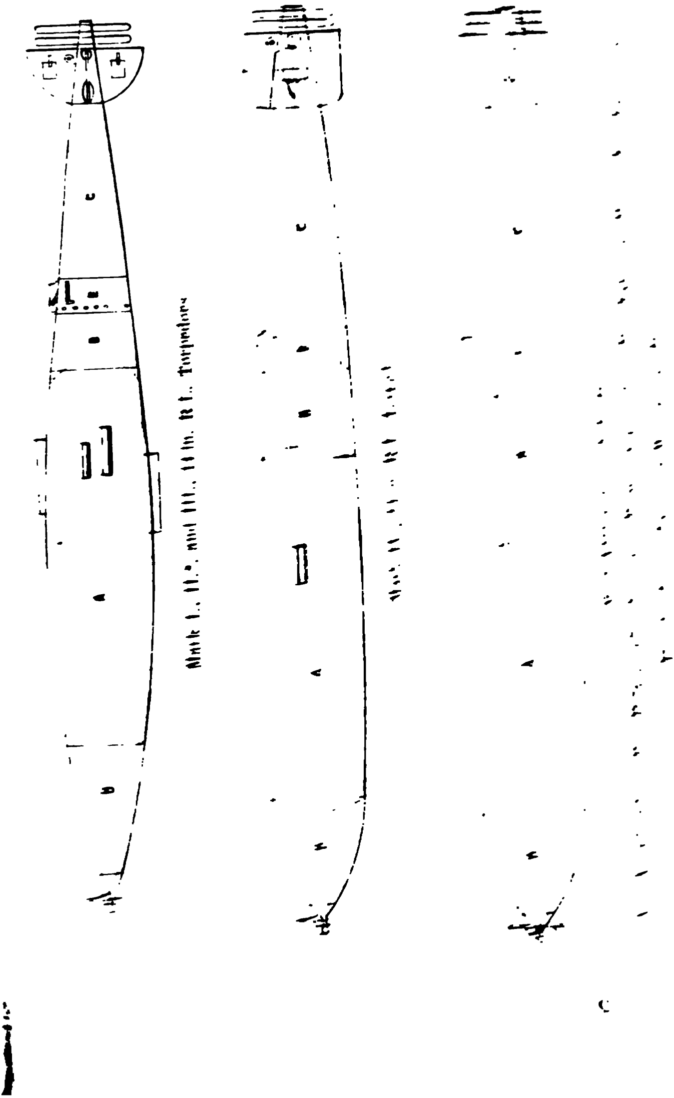
No sooner had our Government completed the purchase than arrangements were at once made for torpedo construction in England on a large scale. Numerous workshops and a large equipment of constructive plant were erected at the Royal Laboratory at Woolwich, and the manufacture of what are known as Mark I * R.L. (Royal Laboratory) torpedoes was commenced. In the meantime a series of experiments was carried out with various forms of torpedo tubes and means of impulse. A submerged tube of new pattern was fitted to the broadside of the *Actæon* and a number of torpedoes were successfully fired from it, the ship proceeding at the time at a speed of about 9 knots. The result was not particularly gratifying, as no less than 30° of deflection had to be given to the torpedoes; still, in spite of this, the trials were considered satisfactory enough to warrant the *Glatton* being fitted with a tube of similar pattern. Since that time the form of tube has undergone several important modifications, and so perfect is the system of release that only about 3° or 4° deflection is now given when firing from a broadside submerged tube with the ship going 18 knots.

Shortly after the adoption of the improved pattern of submerged tube, experiments were begun for finding out the best means of firing torpedoes from above water. It

was recognised that if torpedoes were only to be fired from below the surface their sphere of usefulness would be extremely limited. The first one ever fired from above water was first laid on a mess-table placed inside one of the *Actæon's* ports. The table was inclined at an angle of about 20°, and when all was ready the torpedo was caused to slide off into the water from a height of about 10 feet. Very fair practice was obtained by these means, though when the ship was under way the deflection was very considerable. This deflection, it will be understood, is caused by the nose of the torpedo striking the water first, and therefore being thrown back towards the stern, with the consequent result that the torpedo is deflected in a direction astern of the line of sight. As a result of these experiments the first "above water" tubes for the English navy were constructed for the 16-inch torpedoes, and, as will be pointed out in another part of this book, the adoption of this mode of firing brought into existence a perfectly new kind of war vessel, so much did it extend the usefulness and capabilities of the auto-mobile torpedo.

In 1876 Mr. Whitehead made another great advance by designing torpedoes with a diameter of only 14 inches, with a speed of 18 knots for a distance of 600 yards and a charge of 26 pounds of guncotton. In this year also the inventor fitted what is known as the servo-motor to the steering apparatus of the torpedo. This ingenious little fitting, an account of which is described further on, gave the torpedo a much truer path through the water, as the steering, instead of being jerky and erratic, became almost as perfect as if a mannikin helmsman were steering the torpedo from the inside.

In 1884 the Whitehead torpedo was again thoroughly redesigned. More powerful engines were introduced,


Mark I., II.*, and III., 14 in. R.L. Torpedoes

giving a maximum speed of 24 knots, an increase of 4 knots more than the preceding pattern, and the explosive charge in the head was considerably increased. The mode of firing the charge was also completely changed, as the former plan was rightly considered extremely dangerous. As will be seen later on, the present plan of firing is about as safe as it possibly can be, and any one suicidal enough to attempt to fire a war head on board ship would have to go to considerable trouble to do so.

In 1889, again, another new form of torpedo was constructed. This weapon has a speed of about 28 to 29 knots for 1,000 yards, and a charge of 200 pounds of gun-cotton, and is made by Mr. Whitehead. The 18-inch torpedoes made by the Royal Gun Factory have attained no less than a velocity of 30 knots, and the limit of speed does not appear even to be reached yet. A large number of torpedoes are also made by the firm of Messrs. Greenwood and Batley, of Leeds. In fact, on one occasion this firm received an order from the Admiralty for as many as 420 Mark VIII. torpedoes. The Admiralty are wise in encouraging private enterprise in this way. It requires a considerable amount of pluck to launch out into such a form of business as torpedo manufacture, for the market is limited, the plant necessary to carry it on is large and expensive, and improvements and alterations are always proceeding. Mr. Whitehead's torpedo factory is at Portland, and is presided over by Captain Galway, a retired post-captain of our navy.

The latest pattern of all is Mark IX. R.L. This torpedo is a great improvement over all the others, and its chief peculiarity is that its two propellors are each three bladed. The counter mechanism also is much simpler and more reliable and accurate.

So constant has been the care and attention bestowed on the construction of Whitehead torpedoes, and so many are

the improvements effected in them, that no fewer than twenty-four different patterns exist at the present moment. Many of the older patterns are gradually being eaten away with rust or constant wear and tear, though the newer forms are likely to last a considerable time longer owing to the fact that their working parts are made of non-corrosive metal. The engines, and in fact the whole mechanism, are stouter and stronger. The adoption of what is known as the "controlling gear" (to be afterwards described), the improved system of loading and ballasting the torpedo whereby its stability is greatly augmented, the increased working pressure of the air, and its general finish and delicacy of construction, have served to render the Whitehead torpedo of to-day a veritable marvel of mechanical skill. When one considers that it can be fired from the fastest ships, and make reliable practice no matter what the bearings or speed of the enemy, it is easy to understand its claim for absolute supremacy as an engine of naval warfare.

In the preceding pages an attempt has been made to discuss the genesis of the Whitehead torpedo. It now remains to explain in simple and, as far as possible, untechnical language, the details of its construction, its different modes of firing, and its capabilities, when fully armed, for the stern work of war.

CHAPTER III

THE GENERAL FORM OF THE WHITEHEAD TORPEDO

A WHITEHEAD torpedo is a cigar-shaped object made of steel or of phosphor bronze, and is from about 14 to 19 feet long and from 14 to 19 inches in diameter at its thickest part. In the nose or head of the torpedo is placed (in war time) a large charge of guncotton, or some other explosive. At the head is the end of a pointed rod which penetrates the explosive. On the torpedo coming into contact with a ship's bottom or other rigid object, the point of the rod is driven in against a detonator which explodes the charge, and thereby tears a hole in the ship's bottom. Abaft the explosive chamber is an air-chamber for the purpose of holding the compressed air which acts as the motive power of the torpedo, this air being pumped beforehand into the chamber by air-pumps on board the ship or vessel from which the torpedo is fired. Again, behind the air-chamber is another compartment called the "balance chamber," where all the automatic steering apparatus is fixed, and abaft the balance chamber comes the engine-room. The engines are worked by the compressed air from the air-chamber, and revolve a shaft travelling down the axis of the torpedo, and to the end of which are fixed two screw propellers working in opposite directions. These propellers drive the

torpedo through the water. Furthest aft of all is another hollow air-chamber for the purpose of giving the torpedo the requisite buoyancy. The torpedo is fitted with four rudders, two horizontal and two vertical, the vertical rudders being much smaller than the horizontal ones, which are of course used for the purpose of keeping the torpedo at the proper depth. The torpedo is fired from the vessel's side either from a submerged tube beneath the surface of the water, from a tube on deck or protruding several feet above the surface, or from a slinging apparatus hung over the side of a boat. The torpedo is blown out of the tube by compressed air or a small impulse charge of gunpowder.

In describing the principles and details of construction of a Whitehead torpedo one highly important fact must be remembered. It is impossible within the space allowed to a work of this size, to even attempt a description of the different patterns; and indeed, even if it were possible, those details, highly interesting though they might be to engineering and mechanical experts, would be very dry and technical for the ordinary reader. It will be sufficient, therefore, if a description is given of the general principle of the working of a torpedo's parts, and what may be fairly looked upon as representing the various patterns taken as a whole.

The different patterns of Whitehead torpedoes are divided into six classes, as follows:

Class I.—14 in. Mark I.*, I.**, II., II.*, III., R.L.
Class II.—14 in. Mark IV.*, V.*, VI.*, VII., VIII, IX., R.L. and Leeds.
Class III.—14 in. Mark I., II., III., Fiume and Berlin.
Class IV.—Mark I.* and IV., Fiume.
Class V.—18 in., R.G.F., long and short.
Class VI.—18 in., Fiume.

R.L. = Royal Laboratory. R.G.F. = Royal Gun Factory. Fiume = Whiteheads manufactured at Fiume. Leeds = Greenwood and Batley. Berlin = Schwartzkopff.

Several of these patterns are quite obsolete, yet they are kept in store. A short time ago a consignment of them were at last ordered to be broken up, not only because they were obsolete, but owing to the fact that in the earlier patterns most of the working parts were made of corrosive metal, and had begun to rust and fall to pieces. Perhaps their costliness, about £350 apiece, endears them to the hearts of the authorities; but there is no doubt whatever that a considerable proportion of the 3,500 odd torpedoes in store or on board our ships are utterly unfit for reliable work. Of course, should war break out, the expenditure of them would go on quickly enough, and we should also have plenty of plant and workmen at hand to carry on the construction of new ones.

Mark VIII. R.L. is the torpedo mostly to be found on board our newest ships, and we have a supply of over a thousand of them. A picture of this pattern is given on the opposite page. Opposite page 34 is a photograph of a very early type of Whitehead, and opposite page 47 is a photograph of the 18-inch type. The photographs plainly show the gradual development of the torpedo.

It will be seen that in the earlier pattern of torpedo the head was shaped fine. On first consideration one would imagine that the finer the head the less the resistance to the water. How fallacious this idea is, however, is evidenced at once if we examine the head of any fish which is remarkable for its speed and power of turning. All such fish are bluff-headed and taper away to the tail, and this lesson from nature was taken to heart when the later patterns of torpedoes came to be constructed. In Mark IV.* the head is bluff and the tail fine. In Mark VIII. torpedo, this effect is all the more noticeable, the head being very bluff and the tail fine and likewise attenuated. That this alteration in form is correct is shown by the

increased speed accomplished with but little increase in engine power. Another peculiarity in the construction of the earlier form of torpedo was the perpendicular fin running down its back. In the later patterns this is entirely dispensed with, and the torpedo is kept on a straight course by the perpendicular rudders in the tail.

Having now seen the different forms of the Whitehead torpedo, we will examine the methods and working of its various sections, beginning at the nose first, and gradually working aft to the tail.

The Explosive Head.

The foremost compartment of all is that containing the charge and the pistol with which it is fired.

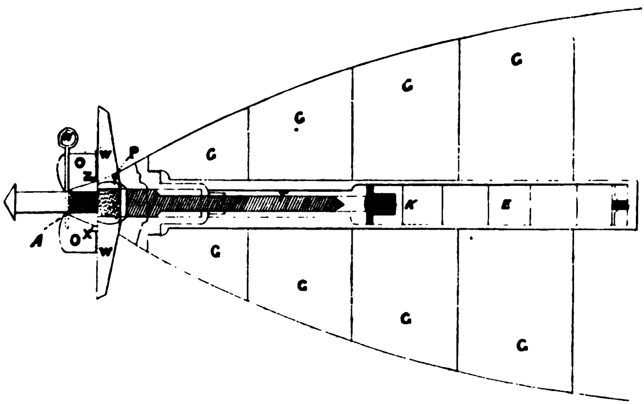


Fig. 2.—Explosive Head with Pistol and Primer.

In fitting the war-head with the firing apparatus, the pistol and primer charge is inserted into its foremost end, all in one piece, and screwed in tight. The body of the

pistol and the striker-tube are made of bronze, and the striker itself is made of nickel-plated steel. A short distance from the foremost end of the striker is a fan O revolving on a screw-thread A. Just abaft this screw-thread is another one on which the whiskers W are screwed tight. The fan O before the torpedo is fired bears up against the whiskers W, but not too tightly, and to prevent its being metal bound against it, a hole X is cut in the corner of three of the whiskers, while the fourth is kept closed and bears against a stud Z. This prevents the fan being tightened up too much and therefore free to revolve, for the holes in the three other whiskers enable them to revolve past the stud, and by the time the fourth whisker is up to it again, it will have screwed forward enough to pass clear. The detonating charge K is 38 grains of fulminate of mercury, and the primer charge E consists of six one-ounce discs of dry guncotton contained in a copper cylinder, the foremost end of which, as will be seen above, is fixed on to the striker tube of the pistol. The rear end of the cylinder is kept tight by an indiarubber ring.

Since the term detonate may cause some readers to say that technical terms have already begun, it may be as well to explain it, and especially so because it is a term very frequently used. An explosion as we generally know it is usually brought about by the application of heat. But according to whether the heat be very great or very slight, applied suddenly or gradually, and whether the explosive be tightly packed in a strong case, or lying loosely on the ground, so will the result of the explosion be greater or less in force. Of course the scientific critic will here step in, nose in air, and say that the total effect is the same, etc.; but speaking generally as regards the result which is attained, the above statement is a fact, as any one may find out for himself; for if the reader will put some gunpowder on a dry board

in a long train, and light one end with a match he will see the train burn without any sound of explosion, as most of us have discovered before we turned our attention to scientific reason. Now put the same amount of gunpowder into a tin case which little more than holds it, put a candle upright in the powder, light the candle, and then place as much distance between you and the tin case as possible, and there will ensue an explosion when the flame reaches it. Thus is the force of an explosion increased by packing the explosive in a case. The same result is obtained by applying a very much greater heat very suddenly to the explosive. But to explain this better, it is necessary to take leave of our old friend gunpowder, which for torpedo purposes is practically played out, and to speak of what are usually called "high explosives." Gunpowder, as the schoolboy knows, consists of nitre, charcoal, and sulphur, which although ground up small and very intimately mixed together, remain always separate, and may be seen through a microscope lying side by side in the mixture. High explosives, on the other hand, are formed by mixing certain substances in such a manner that each substance loses a part of its natural components, and alters its nature, the result being a new substance altogether, perfect in itself, but formed of certain component parts of each of the different things that were mixed together to form it. In fact, gunpowder is like brother and sister who live together, each with his (or her) own individuality, and with different natures; whereas a high explosive is like a well-matched husband and wife, who alter their natures, each one copying the good points of the other and forming an harmonious unit. The high explosives generally used for submarine purposes are "guncotton" and "nitro-glycerine." There are a very large number of others, but they are nearly all founded on one of these two, or on both. Now the effect with a high

explosive is the same as with gunpowder, only more so; it burns if a match is applied to a little of it lying on the ground, and if a quantity in a strong case be ignited it will explode, but not so easily as gunpowder, for it requires more time to get properly lit. There are other ways, however, of applying heat than with a match, viz., by a sudden blow, or a sudden pressure, which is the same thing. The heat that either of these produce is easily seen, thus: bring a hammer suddenly down three or more times on an anvil; the head of the hammer gets quite hot from the blows. Go to a punching machine which makes holes in a half-inch iron plate by pressing the pieces out of the plate, each piece is nearly red hot. Naturally, the greater the blow or more sudden the pressure the greater the heat. Now, returning to the explosive, we have seen that an explosive may burn gently or may explode, and by increasing the heat, blow, or pressure, supposing it always to be confined in the same sort of case, the force of explosion may be gradually increased, until we come to a point when the whole mass seems to explode at once, thereby giving a far greater blow to the atmosphere, the bystanders, or the bottom of a ship, according to its surroundings. When this takes place the term "explosion" is replaced by "detonation," and this is the desired point to arrive at when firing a torpedo against a ship, as the blow being most sudden is more likely to knock a hole in her. The method of detonating guncotton is by means of fulminate of mercury, which, when ignited by a blow, expands to about 2,500 times its own size. This sudden expansion gives a severe blow to the guncotton around it, and detonates it.

When the torpedo strikes a rigid object the striker S is driven in against the detonator K, which detonates the primer E, which in its turn detonates the guncotton charges

G. As may be imagined, however, there are several precautions to be taken in the working of such a dangerous apparatus. It would not do to allow the striker to lie at the mercy of any chance blow against its outer end. So three checks are provided against such a contingency. In the first place the striker cannot go back until the little fan O has revolved off it. When the torpedo enters the water the fan begins to revolve, and travels away from the whiskers until it has run off the screw-thread A. The torpedo runs 40 feet before it has done this. Even then the striker is not in working order unless the blow is a very heavy one, for a little copper pin P is standing in the way, and unless the blow is heavy enough to shear this pin the striker cannot be driven back. When the torpedo, for instance, is in a broadside submerged tube, the play and wash of the water might unwind the fan, so the shearing pin acts as a guard until the actual blow takes place. Then there is a third precaution in the shape of the safety pin M, which holds the fan O fixed until it is withdrawn at the last moment as the torpedo is launched into the tube.

The action, therefore, of the head of the torpedo on being fired is as follows :—When all is ready for firing the safety pin M is removed. As the torpedo rushes through the water the fan O begins to revolve until on reaching a distance of 14 yards it has run off the screw-thread and the striker is no longer hindered by it. Then when the torpedo strikes the object the striker is driven violently inwards, the pin P is sheared, and the point of the striker is driven against the detonator K. Result—explosion.

In using right ahead submerged tubes the construction of the pistol is rather different, the arrangement providing for a longer run, namely, 100 yards, before putting the striker in action. The reason for this will be easily understood when it is remembered that the ship is following the torpedo,

and that the extra momentum given to it by the motion of the ship causes the fan to run off much quicker. There is no need to enter into the details of this arrangement, however. To prevent the mechanism acting when the torpedo is lying in a submerged right ahead tube, a wooden safety check is placed on the end, which flies off when the torpedo leaves the tube. The great danger to be guarded against in using right ahead tubes is the possibility of the torpedo's engines breaking down and the ship overtaking it, but the peculiar arrangement provided gives a good margin of safety.

The head of a torpedo is packed with slabs of guncotton about $1\frac{1}{2}$ inches thick, cut into quadrants, and 17 per cent. of added water, besides being very carefully placed so as to fit closely round the primer canister. In all the later patterns of torpedo the guncotton charge is kept permanently stowed in the war-head, the shell of which is made of phosphor bronze $\frac{1}{16}$ inch thick, the pistol socket and the base-ring being firmly screwed to the shell by screw rivets, and the joint is afterwards carefully soldered to prevent leakage.

Of course, for drill purposes, neither the primer nor war-head is used, but instead a steel dummy head is provided. It is filled with a certain amount of teak ballast carefully packed, and is so arranged that its weight and centre of gravity coincide nearly with those of the war-head itself.

In running torpedoes for exercise, an adjustment is made for causing them to rise to the surface on the completion of their run. As may be imagined, however, it would be a hard job to find such fickle weapons in the open sea, unless there was something else to detect besides a shiny steel fish bobbing about just awash with the surface of the water. So on the head of the torpedo is

placed what is called a "Holme's light." This is an arrow-headed tin canister pierced with several holes and filled with phosphide of calcium. The action of the water on the chemical causes a rush of bubbles to fly to the surface of the water, where on mixing with the oxygen of the air they burst into flame, and give out an enormous amount of garlic-smelling smoke, so that the whereabouts of the torpedo can be known during day or night.

THE AIR-CHAMBER.

As the boilers contain the motive power of a ship, so does the air-chamber contain the motive power of the torpedo. Its position is next abaft the explosive head, and its relative size to the whole torpedo will be seen on reference to the diagram facing page 16.

It is made of a solid piece of finest Whitworth compressed steel, just a trifle under ·3 inches thick, and its ends are convex so as to better stand the enormous pressure to which it is subjected. Sighting plug-holes are also fitted in it to allow for examination of the interior.

The air in the chamber is compressed into it by means of air-compressing pumps fitted on board. There are various forms of these pumps, but perhaps the most common form is that invented by Brotherhood. A tough copper tube connects the compressing engines to the torpedo when it is being charged. In Mark VIII. R.L. torpedo, which may be taken as a representative modern type, the air is forced in to a pressure of 1,100 lbs. to the square inch for purposes of exercise, and of 1,350 lbs. for action. In the older patterns the maximum pressure has only about 1,000. In the Mark VIII. torpedo the chamber is actually tested to a pressure of 1,700 lbs. to the square inch, a

wonderful proof of the strength of the steel of which the chamber is made.

It is very curious to note the extraordinary weight of the air in the torpedo when charged. In Mark. VIII. it weighs over 30 lbs., whilst in the 18 in. Fiume, Mark I., the weight of air is no less than 63 lbs. This shows how the fact of the air being compressed reduces the buoyancy of the chamber. If the valve at the top of the torpedo is opened ever so slightly, the air rushes out with such extraordinary force that it can actually keep a small spanner dancing about in mid air, when carefully poised. If too the air-chamber explodes, as it sometimes does when a torpedo which is being run for exercise strikes a ship, the concussion and noise rivals the explosion of gunpowder, while the pieces fly like the fragments of an exploded shell. This, however, has only happened twice, once in Cawsand Bay and once at Fiume, when the torpedoes which were being run for exercise struck the rocks. Both these torpedoes were Mark I., 18 in. Fiume. The air-chamber is examined internally in the ordinary course of events about once in every three years.

The Balance Chamber.

The balance chamber of the Whitehead torpedo is that compartment lying next abaft the air-chamber which contains the apparatus that controls the torpedo at its proper depth in the water. In addition, it also contains various valves through which the air passes on its way to the engines from the air-chamber, and it will be as well to describe these latter first, before entering into the mechanism of the balance chamber proper.

The air in leaving the air-chamber first passes through a pipe which leads to what is known as the "stop valve."

THE STOP VALVE.

The use of the stop valve is to prevent as far as possible any leakage of air while the torpedo is kept charged. The high pressure in the air-chamber renders such a valve absolutely necessary, and as it is, the air escapes gradually if the torpedo remains uncharged for any time. It also enables the torpedo to be parted into sections for examination without discharging the air in the chamber, and is also very useful for regulating the supply of air when working the engines or taking adjustments of the horizontal rudders.

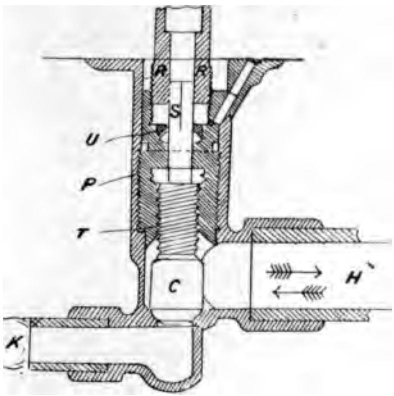


FIG. 3.—STOP VALVE.

C, stop valve; H, pipe to valve; K, pipe to air-chamber; P, stop valve casing; R, stop valve spanner; S, square on valve spindle; T, upper seating of stop valve; U, gland nut.

P is the casing of the valve, and is secured to the upper part of the balance chamber. It is connected on one side by the pipe K, which leads to the air-chamber, and on the

other by the pipe H, which leads to the starting valves and the engines. In the event of its being necessary to cut off the supply of air from the air-chamber, the valve C is screwed hard down by means of a stop valve spanner R, which fits into the square end S of the valve spindle. In the plate the valve is shown closed hard down, and the spanner R cannot be removed until it is unscrewed again and its bottom is clear of the threads, when the valve should be open. This arrangement of screwing the spanner into the valve while the stop valve is shut is done as a precautionary measure. It prevents the possibility of the torpedo being placed in the tube or discharging apparatus with the stop valve shut, as the handle would stand in the way, and indicate at once the fact that the torpedo was minus motive power. When the valve is open, the upper part of C bears tightly against the lower edge of T, and thereby prevents any leakage of air up through or past the valve spindle.

Before tracing the passage of the air from chamber to engines any further, we will examine the charging valve, which is in the engine-room, and is shown on the right of Fig. 4.

THE CHARGING VALVE.

The charging valve marked A in the diagram serves the purpose of a non-return valve for the entry of air into the torpedo from the charging reservoir. A solid plug E is unscrewed from the socket T, and the charging nozzle is screwed in instead. To this nozzle is attached the air pipe leading from the reservoir. The stop valve (already described) is then opened, and the air is pumped down the pipe into the valve opening. The pressure of the incoming air then forces the valve A downwards and compresses the

spring F underneath. The air is then free to pass through the valve, along the pipe G into the pipe H leading to the stop valve and air-chamber. When the torpedo is charged sufficiently, the stop valve is closed and the charging nozzle is gradually unscrewed and withdrawn. The action of the spring F, and the pressure of the air underneath,

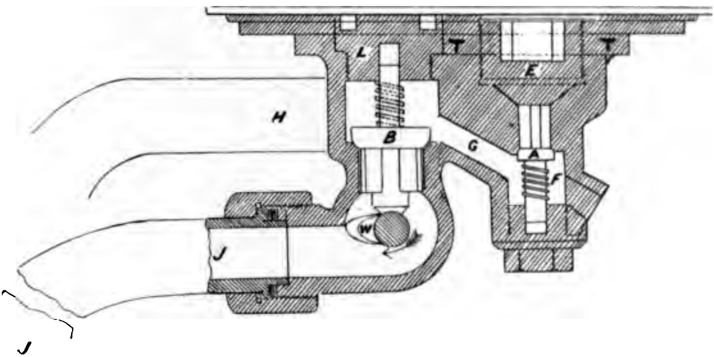


FIG. 4.—STARTING AND CHARGING VALVES.

then forces the valve A up again to its proper place, and the valve is closed. The plug E is then replaced.

We will now resume tracing the passage of the air from chamber to engines.

After leaving the stop valve the air passes along a pipe until it reaches the starting valve.

THE STARTING VALVE.

The starting valve is the medium by which the air is turned on to or cut off from the engines. Its action is as follows:

In the diagram, B is the starting valve which admits air to the engines. It is lifted up and thereby opened by the cam W, which is connected to the spindle of the air lever. The top of the air lever is fitted with a small metal flat piece which lies just above the upper surface of the torpedo. When the torpedo is launched from the tube, a projection inside the latter throws the end of the lever backwards, and the cam W is thereby turned upwards. The effect of this is to lift the valve B off its seating, with the result that the air passes from the pipe H through the starting valve into the pipe J, and onwards to the engines. To prevent any danger of the air lever being jerked forward again on the torpedo striking the water, a small friction spring is fitted to it. When the torpedo has completed its distance, the air lever is thrown forward again, the cam W turns downwards, and the spring and air pressure above the valve B pushes it down into its seating. Thus the air is cut off from the engines, and the torpedo stops.

The mechanism which enables the torpedo to be adjusted to any required distance will be explained subsequently.

After going through the starting valve, the air passes on through the pipe J to the delay action valve.

Delay Action Valve.

It will be easily understood that were no check placed on the engines as the torpedo is in the act of passing from the tube into the water, there would be a tendency for the propellers to revolve at a tremendous rate owing to their having no water acting against them as a resisting medium. In fact, with the newer form of torpedo this would revolve at no less a speed than 2,000 revolutions a minute, which would mean a great strain and shock to the torpedo.

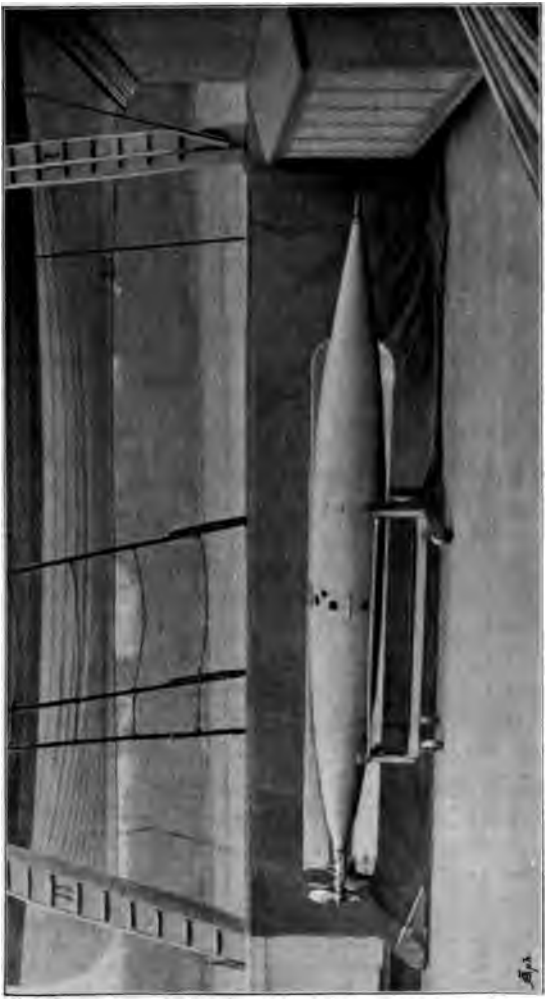


FIG. 5.—OLD 16-INCH WHITEHEAD TORPEDO.
(Showing the pointed head of the older type.)

To remedy this, the "delay action valve" is fitted. It is represented by D in the diagram. This valve lies loosely in its seating M, and is pierced with ports marked K. The seating is also pierced with ports marked Z. When the torpedo is passing through the air the valve is resting as depicted in the diagram, with the result that what little air passes through it is forced between the valve and its seating. Attached to the valve D, however, is a lever having a flat water tripper fitted to its upper end, and projecting just above the surface of the water. When the torpedo strikes the water, the tripper, with the lever attached, is thrown back, and the valve D is turned round until the ports Z and K are open to one another and the air is free to pass through to the engines with full force.

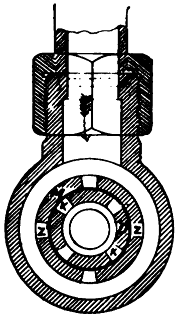


FIG. 6.—DELAY ACTION VALVE.

After being admitted through the delay action valve, the air passes on to the reducing valve.

THE REDUCING VALVE.

The object of the reducing valve is to insure the air being admitted to the engines at a uniform pressure throughout the run, and not at a high pressure at the commencement and a low one at the end as would be the case if this valve were not fitted.

The air passes through the pipe C up into the centre of the valve K. The valve consists of a metal ring pierced with ports covering an inner ring also pierced in the same manner. The outer ring has attached to it a spindle S resting

on a flange F, and kept hard down into place by a powerful spring. As the air enters the valve it passes through the ports of both rings into the space A. If, however, the pressure in A becomes too high, the outer ring is forced up against the spring and the flange F rises, and the ports are gradually closed to one another. This prevents the free passage of air, and immediately the pressure in A again falls and the ports open again. Thus during the run of the torpedo the reducing valve is trembling up and down the whole time, cutting off and admitting air as the pressure rises or falls.

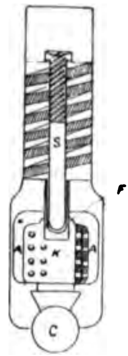


FIG. 7.—REDUCING VALVE.

After leaving the reducing valve the air is allowed to pass into the slide valves of the engine.

We have now followed the air in its carefully conducted passage from the reservoir to the engine-room, but, before dealing with the mechanism of that part of the torpedo, we will complete our examination of the balance chamber, with all its ingenious apparatus for controlling the torpedo at its proper depth in the water.

THE STEERING APPARATUS.

The steering apparatus in the balance chamber is worked from two sources. One is a swinging weight delicately pivoted, and the other is a valve which is kept in its place by a spring, but is forced in by the pressure of the water when the torpedo goes below a certain depth. The mechanism differs in different torpedoes, but its essential parts are practically the same. The pendulum weight swings in a fore and aft direction, and is connected by rods to the rudder.

When the torpedo is head downwards the weight swings forward, and the rudders are brought up, thereby steering

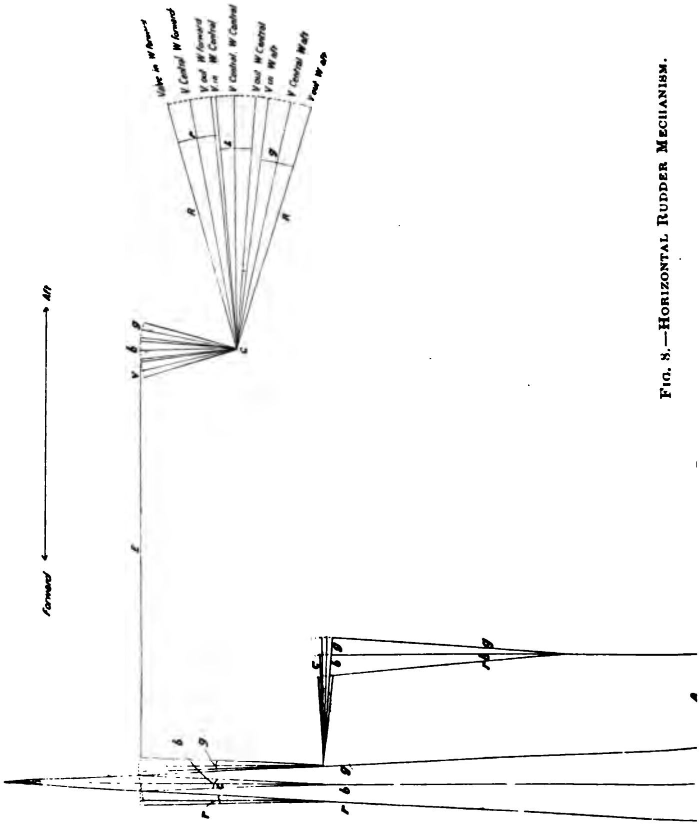


FIG. 8.—HORIZONTAL RUDDER MECHANISM.

the torpedo upwards again. When the torpedo is point up *the reverse* happens, and when it is level the rudders, so

far, at least, as the pendulum acts upon them, are level also.

The disc, already referred to, has a limited travel, and although freely exposed to the pressure of the water, none is permitted to enter the interior of the chamber, this being prevented by a loose collapsible piece of indiarubber, which keeps the valve watertight without interfering in any way with its action. When in its normal condition the disc is kept forced out by the spring inside it to the full limit of its travel, but as the torpedo descends in the water, the pressure increases until the depth at which it is intended the torpedo shall run is reached, when the valve is forced in. A rod connected to it transmits its motion to a lever pivoted to the arms holding the weight of the pendulum, the other end of the lever being joined by a series of connections to the rudder.

The diagram on the opposite page will give an idea as to the dual working of these two adjustments.

For example. The torpedo has just left the tube and has shot down below its proper depth and is still pointing downwards.

The weight will be forward.

The disc will be forced in.

The result is that the pivot point on the pendulum arm is pulled forward, and simultaneously the rise of the valve causes the after end of the small horizontal lever to lift, and the upper end of the upright arm, which is joined at right angles to it, to move forward. The result is that you have the long lever E moved forward first by the pendulum arm, and further again by the small lever, or, in other words, it is moved forward to its fullest extent. This brings the little lever pivoted on G, right forward also, and the rudder, which is fixed at right angles to it, is lifted hard up. The effect of this of course is to bring the torpedo upwards again.

By following the different directions and positions of the torpedo in the diagram, the effect of the various combinations can be traced out, and it can clearly be seen how the action of one adjustment checks the action of the other.

Controlling Gear.

There is one adjustment made to the balance mechanism which is called the controlling gear. When the shock of discharge takes place the pendulum weight would be thrown violently backward, and the rudders would be interfered with in their action. The controlling gear prevents this, and keeps the rudders fixed for a certain distance, releasing the mechanism when the torpedo has reached its proper depth and distance.

Having now examined all the various contrivances to be found in the Balance Chamber, we will pass aft to the next compartment, namely the "Engine Chamber."

The Engine-room.

Inside the engine-room are contained what are termed the servo-motor and the engines, and the charging valve already described.

The Servo-motor.

With the introduction of the 14 in. torpedoes, it was discovered that the mechanism of the balance chamber was not anything near powerful enough to work the horizontal rudders direct. The reason of this was due to the speed of the new type and the consequent increase of pressure on the rudders.

Accordingly a servo-motor was designed for the purpose

of supplying power to the rod when moved by the balance mechanism, in the same way as a steering engine magnifies the power of the helmsman.

The servo-motor is only about four inches long, but its power is so great that with only half an ounce pressure on the slide valve the piston is capable of lifting 180 lbs.

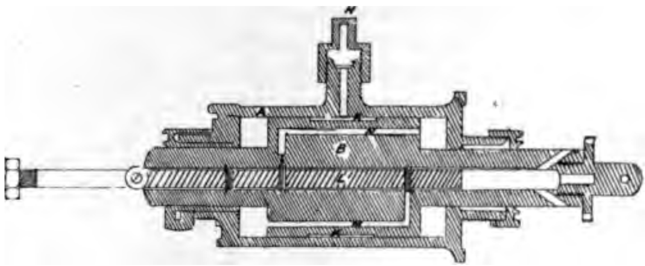


FIG. 9.—SERVO-MOTOR.

In the above diagram A = cylinder, B = piston, L = cylindrical slide valve.

The action is as follows:

When air is admitted to the main engines, it enters at the same time by a passage through the small pipe H to the annular space K round the piston B, and then passes on through it to the annular space and round the centre of the slide valve. In the diagram the slide valve is centred, and the collars are both closing the openings to M and N.

Now, suppose the slide valve is moved forward by the balance mechanism.

The left collar moves away to the left, so that the after-side of the piston becomes open to supply by the passage N, whilst any air on the fore side is free to exhaust through the passage M, the right collar having also moved from its opening, and thus through the diving tube and out

of the tail. The result is the piston moves forward with the diving rod, and the rudders are turned up. The reverse action, it will easily be seen, takes place if the slide valve moves aft.

So whichever direction the slide valve, actuated by the balance mechanism, moves in, the piston follows it to exactly the same extent.

In the fore end of the diving rod a spiral spring is fitted in such a way that at the completion of the torpedo's run the rudders are brought slightly upwards, so as to provide against any tendency on its part to dive.

All torpedoes, except Mark I. Fiume 14″, and Schwartzkopff, are now fitted with the servo-motor.

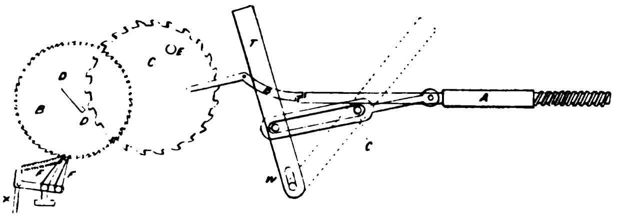


FIG. 10.—COUNTER MECHANISM.

COUNTER-MECHANISM.

The above is a rough diagram showing the method of stopping the torpedo after it has run its prescribed distance.

As the engines revolve, the two arms F, F, are worked up and down by the rod X, which is worked by the main engines. These little arms work into the teeth of the small wheel of counter B, and move it on one tooth each revolution of the engines, which corresponds to a yard, the pitch of the propellers being thirty-nine inches. Attached

to the centre of the small wheel of counter are two studs, D, D, which, as the small wheel revolves, gear alternately into the teeth of the large wheel of counter C, thus moving the latter two teeth for every complete revolution of the small wheel. On the large wheel is a projecting stud, E.

A bar A, actuated by a spring, presses against a bent lever B; and pivoted to A is a steel bar and loop. The upper end of this loop in the diagram is bearing against a stud C on the air lever T. This air lever, as has been explained in a former page, is connected to the cam W of the starting valve.

As the large wheel slowly revolves, the stud E at last bears against the end of the bent lever B, presses it down and raises its other end. The bar A is thereby released, flies forward, carrying the loop bar with it, and the stud C with the air lever T is thrown also forward, and the cam W is turned down. The starting valve therefore is shut, the air is cut off, and the engines stop.

The torpedo is adjusted for distance prior to running by simply moving the large wheel round until the stud S is the proper number of teeth away from the end of the lever B. Allowing 10 per cent. per slip, each tooth stands for forty-five yards of run.

THE ENGINES.

The engines are single acting three-cylinder ones, and are made by the firm of Messrs. Brotherhood. The crank chamber and casings for the slide valve form one casting, the valves themselves being of a cylindrical form. Unlike the ordinary slide valve of a steam engine, they perform only the operations of admission and cut off, the exhaust taking place through the ports in the end of the cylinder. The great advantage of these three-cylinder engines is that

there is no possibility of their being hung up through getting on a dead point. The indicated horse-power of a Mark VIII. Whitehead is no less than 30·8.

The Buoyancy Chamber.

Next abaft the engine compartment comes the buoyancy chamber, and its purpose, as its name denotes, is to give the necessary buoyancy to the torpedo.

The engines themselves are shut off the buoyancy chamber by the bulkhead to which they are secured. In the centre of this bulkhead is a door in which the tube for the propeller shaft is permanently fixed, the tube being enlarged at its fore end so as to take the coupling of the crank and the propeller shafts.

The shaft passes right through the buoyancy chamber, and the bearings are made thoroughly watertight by means of asbestos packing. The diving rod connecting the balance chamber mechanism with the rudders also passes through the chamber, and the sinking valve is fitted in the forward bulkhead.

As may be imagined, the chamber is subjected to considerable outside pressure, and to guard against any collapse, flat steel rings are fitted into it for support.

To ensure the torpedo being always in a perfectly upright position, a certain amount of ballast is kept stowed in the bottom of the chamber.

The Tail.

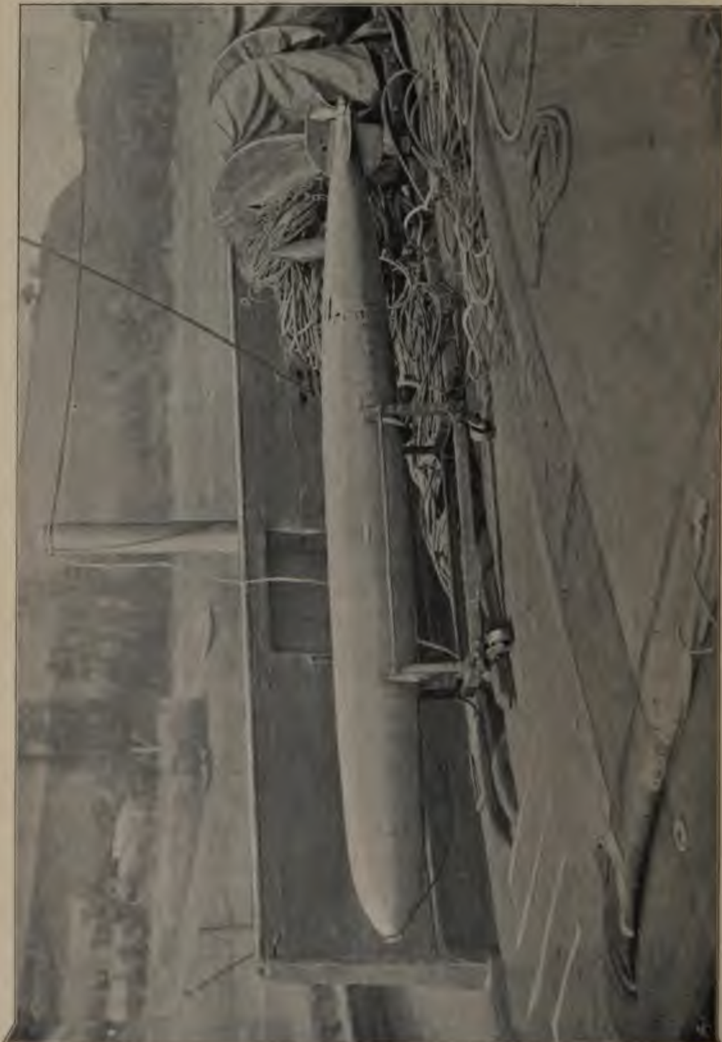
The rearmost compartment of all in the torpedo is known as the tail.

It forms a continuation of the buoyancy chamber, and contains (1) the wheel gearing for turning the propellers

in opposite directions; (2) the upper and lower perpendicular fins, and the frame holding two horizontal rudders; (3) the vertical rudders; (4) the horizontal rudders; and (5) the propellers.

The wheel gearing for turning the propellers in opposite directions consists of a system of mitre wheels. The perpendicular fins are placed as shown in Fig. 1, and in the photographs. The horizontal rudders, which, as has been explained, are worked by the balance mechanism, are pivoted on a frame on each side of the conical tailpiece, and the vertical rudders are pivoted on the horizontal tail frame, but as may be understood, after having once been adjusted they are not altered. The pitch of both propellers is the same, namely, three feet, and the diameter varies very slightly.

The vertical rudders can be easily set to any angle up to twenty degrees by means of a clamping screw, but, as may be easily understood, they are not much used. The horizontal rudders are connected to the steering rods, which pass through holes on each side of a cross-head.



CHAPTER IV

TORPEDO TUBES—DIRECTOR—AIR COMPRESSOR—CHARGE AND CARE OF TORPEDOES—DRILL AND PRACTICE—TORPEDO DEPOTS

Torpedo Tubes.

THERE are four different patterns of weapon for the propulsion of Whitehead torpedoes, namely—submerged, above-water, and revolving tubes, and boats' "dropping gear." To describe these weapons in full detail would only weary the reader with technicalities which would be hard to grasp readily, and would afford little general interest. A description of the Whitehead torpedo, however, would necessarily be incomplete without a proper description of the mode of firing it.

A torpedo tube may be roughly described as a large metal tube open at one end and closed by a hinged door at the other. The torpedo is placed inside, and is suspended in the tube, its side lugs resting on two narrow ledges inside it. The torpedo is blown out of the tube either by compressed air suddenly injected into the rear end, or by an impulse charge of a few ounces of powder; for owing to the torpedo fitting nearly tightly into the tube the pressure from the air or the powder gases only acts on its rear end. The air pressure varies from 300 to 600 lbs. to the square inch, and the powder charge from 4 oz. to 4½ oz.

The most difficult and complicated mode of firing Whitehead torpedoes from a ship is by means of submerged tubes, that is to say, tubes constructed in the ship's bow or side below the water line. There is one great advantage in this system, however, namely—that it is by far the safest, there being little or no risk of the torpedo being struck by the enemy's shot or shell before it leaves the ship. In a hot action the use of above-water tubes will be an exceedingly ticklish and dangerous business, for should the head of the torpedo be violently struck the destruction which it would deal out to its users would be too awful to contemplate. In Mr. Arnold Forster's excellent little brochure entitled *In a Conning Tower* the enemy is made to lose the battle through the confusion caused on board of her by the explosion of one of her torpedoes in its tube before it is launched, and the author's suggestion is not by any means a far-fetched one. On the other hand it requires more than a machine gun bullet to fire a torpedo prematurely. A series of carefully conducted experiments have shown that unless the detonators themselves are struck, the charge will not explode, the immutability of gun-cotton to blows or concussion allowing the head of the torpedo to be perforated over and over again by bullets without any explosion taking place—always of course providing the detonators are not injured. Still the dangers of above-water discharge are so numerous that it is more than likely that few torpedoes will ever be launched from ships in action except from submerged tubes, where the risk to the operators is reduced to a minimum.

A submerged tube differs but slightly in shape from the above-water one, except that it is provided with an outer cap which can be opened or shut at will. When the tube is being loaded this outer cap is closed and a sluice valve is opened which allows the tube to be drained of the water

FIG. 12.—WHITEHEAD TORPEDO IN THE ACT OF BEING FIRED FROM THE STERN OF A FRENCH CRUISER.

E

inside it. The torpedo is then run into it, the inner door closed, the firing arrangements (which in this case are actuated by compressed air) are connected up, the tube flooded and the outer cap opened to allow open access to the water outside. When the torpedo is in its place in the tube a guiding bar is run out by means of pneumatic power. This guiding bar is used for the purpose of holding and guiding the torpedo until just clear of the ship, when by means of a secret apparatus it releases the torpedo at both ends simultaneously. By this arrangement the torpedo is enabled to leave the tube and start on its course with but very slight deflection. It will be easily understood that without the guiding bar the torpedo would be enormously deflected towards the stern directly it began to leave the tube, but so ingenious is the system of release that not more than seven degrees of deflection are ever allowed for, when using submerged tubes, even when the torpedo is fixed broad on the beam and the ship is travelling at a high rate of speed. This releasing mechanism is so ingenious and effective in its action that whereas in our Navy the deflection of the torpedo is only seven degrees, in the French Navy it is as much as fifteen. Consequently every precaution is taken against foreigners learning anything about it, and the less said about its working therefore the better. It is probably the most valuable secret which our torpedo service possesses, and that is saying a good deal.

There are no less than sixteen different patterns of 14-inch "above-water" tubes, and three patterns of 18-inch tubes in use in the service. In the oldest pattern of all, namely Mark III. the torpedo was ejected from the tube by means of an impulse rod, which was after the fashion of a telescope and blown out to its full length by

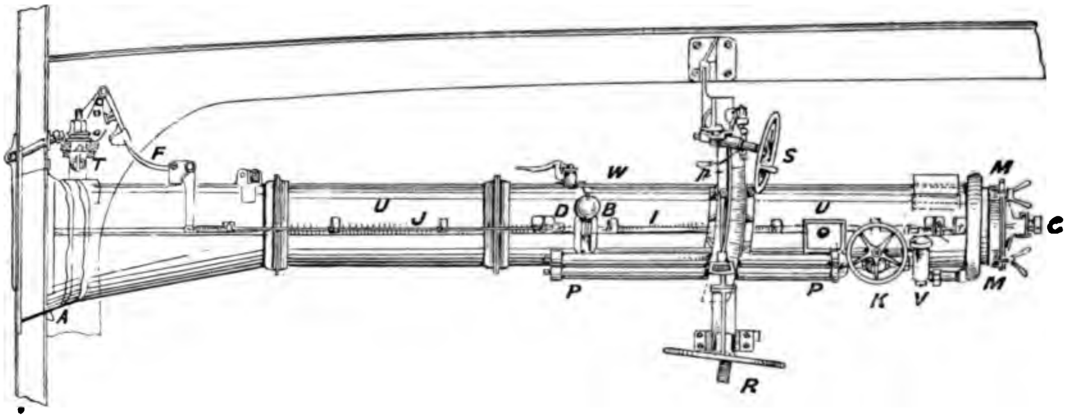


FIG. 13.—MARK VII. B. TORPEDO TUBE.

E 2

compressed air, the rear end of the torpedo resting against, and being pushed out by, the rod.

There are also various turret-ship tubes which are adapted to the peculiar requirements of their respective ships, and are classed by themselves.

The diagram on page 51 gives a general view of a Mark VII. B torpedo-tube. UU is the tube itself working on the pivot T. S is the revolving handle which actuates the training gear. The bracket p acts as a carriage or supporter for the tube, which is elevated by the screw handle R, the amount of elevation being recorded on a graduated arc on the carriage. W is the "tripper" for the torpedo (already described). PP is the firing reservoir for the compressed air, and O is the box containing the contact maker. The little wheel K works the "stand by" valve for the air. V is the firing valve, which is worked by the firing rod I, which again in its turn is actuated by the magnetic firing gear at B. To prevent the torpedo being fired before the opening is free, an automatic locking lever F is connected up to a locking rod J, which, by means of a clutch D, prevents the firing rod I turning and discharging the torpedo. When the opening is free the lever F moves so as to cause the rod J to move away from and unclutch the firing rod, thus leaving it free to turn, and fire the torpedo. A is the canvas diaphragm protecting the opening, and C is the pocket where the impulse charge of powder rests. MM is the door of the tube.

The torpedo is fired as follows: When the circuit through the wires leading to the conning tower is completed by the officer in charge, the electro magnet at B is put into action, and releases the heavy ball Z, which falls down, and in doing so turns round the firing rod I. The "stand by" valve having been previously opened, the air is thereupon suddenly released from the reservoir, passes

through the firing valve at v, and exerts its pressure in the rear end of the tube with the result that the torpedo is blown out. When using powder only the torpedo is simply ejected by the explosion of the impulse charge in the pocket c. The cartridges containing these charges are made, as has been already pointed out, in two sizes, namely, 4 and 4½ oz. of pebble powder, and are closed at the bottom by a varnished cardboard disc. A wireless brass electric tube containing priming composition is inserted in the centre of the cartridge case. The cartridge is fired by the fusing by electricity of a platinum wire bridge inserted in the priming charge. The cartridge is entered from the outside of the door, and is kept in its place by a hinged flap.

The foregoing description of an above-water tube may be taken as following the general lines of the different patterns of those tubes in the service. Although the impulse charge of powder is so small, it is surprising what a tremendous difference it causes in the behaviour of the torpedo if the slightest alteration is made. An increase in the impulse, be it ever so slight, will tend to bring the torpedo to the surface, and a decrease will make it dive. The torpedo when it leaves the tube has no higher velocity than about 25 or 30 feet per second; consequently it strikes the water but a few yards from the ship and in a fairly horizontal position.

Revolving tubes are carried either singly or in pairs on board torpedo boats and destroyers. In some boats they are mounted and constructed as shown in the photograph on the next page. In others they are mounted one on each side of a small conning tower where is stationed the operator. They are mounted on circular racers and are so fitted that they can be loaded when trained in the fore and aft position. Powder impulse only is used. When not in use or ready

for action they are trained fore and aft so as to bring their centre of gravity over the keel of the boat and thus prevent heeling or rolling. Experiments have been made with aluminium tubes with a view to reducing their weight, as it is extremely necessary to lessen this as much as possible, owing to their tendency to make the boat topheavy. These experiments however have so far not been very successful, the aluminium being scored in the tube, and suffering from the chemical action of the powder gases. It should be mentioned that cordite is now gradually replacing the pebble powder hitherto used in the impulse charges.

Another mode of firing torpedoes from second-class torpedo boats and picket boats is by means of what is called "dropping gear." This consists in slinging the torpedo at each end with a pair of clip tongs, and suspending it in a horizontal and fore and aft position out clear of the boat's side. When the moment for firing arrives the tongs are opened simultaneously and the torpedo falls flat on to the water, the engines being at the same moment set in motion. The tongs are suspended from pivoted davits so that the torpedo can be kept hoisted up well clear of the water until the last few moments. The torpedo is of course aimed by directing the boat's head direct for the object fired at. The arrangement of the dropping gear is plainly shown in the photo of the second-class boat on page 203.

Some torpedo boats are supplied with fixed bow tubes, and all torpedoes in boats are run into their tubes by running them off a tray in rear of the tube. There are also various patterns of fixed tubes in different ships, all differing in certain particulars but all constructed on the same principles.

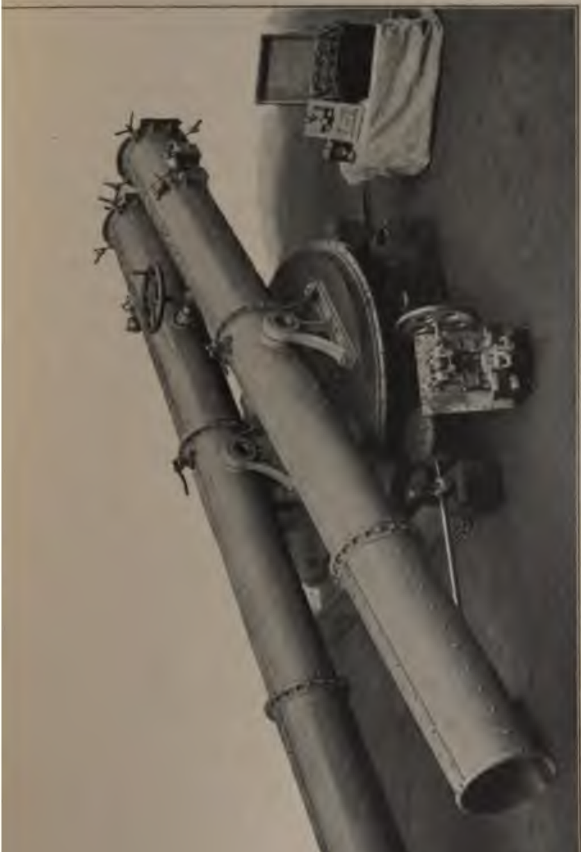


FIG. 14.—A PAIR OF TORPEDO BOAT TUBES (DISMOUNTED).

The Torpedo Director.

As will be easily understood there are no means of directing torpedo tubes at the enemy in the same way as in the case of guns. They are often under water or else hidden inside the ship's side, and consequently have no sights fitted to them. An arrangement is therefore made whereby they are fired by the help of what is called a "director," which is placed some distance away on deck, and takes the place of what otherwise would have been ordinary "sights." The director is generally used by the officer in charge of the torpedoes, and when the sights on it are properly aligned, he fires the torpedo down below by simply pressing his hand on an electric key, which completes a circuit connected with the firing apparatus on the tube.

There are two kinds of torpedo directors in the navy, but it will suffice if we confine ourselves to a description of one of them, namely—that for broadside tubes of ships. The other is similar in principle.

The director (which is shown on opposite page) is made of brass, and the arc, *R*, is graduated to degrees in the same way as the racer of the tube down below. A radius bar, *T*, works along this arc, and is graduated for the speed of the torpedo. Pivoted also from the centre is a sight bar, *F*. Lying across these two bars is a third one, *E*, which is graduated to show the speed in knots of the enemy, and is clamped at each end on to the two bars.

Suppose the torpedo is being fired from a training of 30° before the beam, the ship is going 15 knots, and the enemy passing at the estimated speed of 12 knots, the speed of the torpedo being 20 knots.

The bar *T* is first trained to the mark on the arc *R* for

30° before the beam. A correction, obtained from a table at hand, is added to it for the speed of the ship, the deflection being allowed on the arc abaft the training of the tube. The clamp connecting the bar *E* to the radius bar is moved to the mark for 20 knots (the speed of the torpedo), and the clamp connecting the sight bar to *E* is

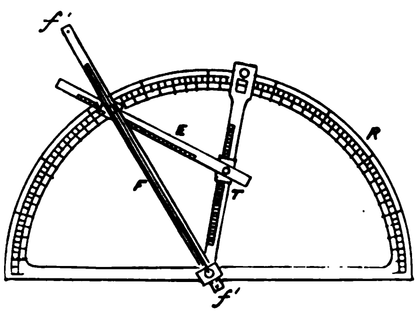


FIG. 15.—TORPEDO DIRECTOR.

adjusted to the mark for 12 knots (the speed of the enemy), the bar *E* having been directed so that the arrow mark on it points in the same way as the enemy is going. On the sight bar are two notched sights, *f′*, *f′*, and when the enemy comes in line with them the key is pressed and the torpedo fired.

Air Compressor.

The air reservoir of the Whitehead torpedo is charged by means of air compressing pumps fitted on board the ship. In torpedo-boats one set of pumps is generally fitted, and in destroyers and larger vessels two or more. The most common form is Brotherhood's, and all have to be constructed of a special make owing to the very high pressures

which they have to create. On board torpedo boats the torpedoes are recharged nearly every morning, as it is found that in spite of every precaution the air has an obstinate habit of gradually escaping. The operation of charging is not a very lengthy process providing the pumps are in good working order. They generally work at the rate of about 300 revolutions per minute and require a steam pressure of about 60 lbs. The method of conveying the air from the engines to the torpedo has been already explained.

Charge and Care of Torpedoes.

The torpedo lieutenant, when he forms part of the complement of a man-of-war, is the officer who has charge of the torpedoes. His special duties also extend to the maintenance of the electric installation throughout the ship, including both search lights and incandescent lamps, and his control and responsibility stops at the poles of the dynamos, where the engineers take charge. There is often a dispute regarding this latter point, for whereas the captain generally leaves it to the torpedo lieutenant's discretion as to when and what dynamos shall run, the engineers have to keep them in working order. The air-compressing engines are also in charge of the engineers, though of course the torpedo lieutenant gives the necessary orders for their use. The most important duty of the torpedo lieutenant however is the charge and care of the torpedoes and launching gear, and the mines. The stores are placed in custody of the gunner of the ship.

As has been already explained, Whitehead torpedoes require an extraordinary amount of care if they are to be trusted to do their work properly. The different working parts, and the shell of the torpedo itself

have to be jealously guarded from rust, and constantly examined. Each torpedo has its own history-sheet, in which is entered the particulars of every run which it makes and every alteration or repair effected. By this means the idiosyncrasies of any particular torpedo can be known at a glance, and due allowances made accordingly. The writing up of this history-sheet is done by the torpedo lieutenant or whatever officer is deputed by the captain to undertake his duties. When a torpedo lieutenant is not carried, the gunnery lieutenant is generally given charge of the torpedoes and mines.

Torpedo Drill and Practice.

Certain distinct regulations are laid down by the Admiralty regarding the regular practise with torpedoes. A number of them are too detailed and technical to interest the general reader, but a few extracts from them will give a fair idea of the regularity with which the torpedoes are tested and their crews kept generally up to the mark.

Every month, all the circuits, batteries and instruments throughout the ship are thoroughly examined and tested. Every quarter Whitehead torpedoes are run from the ship when in harbour at the rate of two runs from each tube. In the same period also two runs are given from each tube with the ship under way. Every half-year the discharging apparatus is thoroughly overhauled, and the torpedoes carefully gauged. Every year the warheads and guncotton are weighed and tested, and every three years an internal examination is made of the air chambers. So it cannot be said that the torpedoes or their crews are allowed much chance of getting rusty.

Every ship or boat which carries torpedoes has a crew told off to each tube just in the same way as a crew is told off to each gun. Likewise these torpedo crews are exercised as often and as thoroughly as the guns crews, but their work has one great peculiarity, namely, that it differs largely in different ships. That is to say torpedo tubes, and submerged ones in particular, are not all built of the same size and shape as a certain pattern of gun, but rather are built to suit the ship they belong to. The consequence is that in many ships a drill has to be prepared for the submerged tubes, which applies to that ship alone.

Still there are various fixed drills laid down in the drill book, which may be said to be applicable to some, at least, of the tubes in every ship fitted with Whiteheads. The chief ones are those for torpedo boats with revolving tubes and right-ahead tubes; steam boats' dropping gear; above-water tubes in ships; and broadside submerged tubes. It would be impossible to make even an attempt within the scope of such a small volume as this to enter into the actual details of each drill, and even if it were so it would be far too dry and technical for general reading. Yet it may be worth while to touch lightly on the subject of the torpedo crews, and obtain some slight idea of their action and duties.

Let us take, as an example, the working of an above-water tube.

The full torpedo tube's crew consists of six men, namely, a leading torpedo man as captain of the tube, and five men, three at least of whom must be a seaman, gunner, and torpedo man. This number of men is not sufficiently strong to hoist the torpedoes up from below, so when the time comes to provide the torpedoes for the tubes the different torpedo crews combine together to man the tackles and hoist

Fig. 16.—Torpedo Crew Entering Torpedo into a Tube.

them up. When quarters are sounded the crews fall in behind their respective tubes in single rank. At the order "close up" the crews range themselves on each side of the tube as follows,—1 in rear of the tube, 2 on the right in line with the door, 3 and 5 on the left of the tube, 4 and 6 on the right. At the order "cast loose" 1 superintends generally while the crew clear away the securing chains and plugs, and connect the pivoting bolts, each number having, as in all the rest of the drill, his own particular job allotted to him. When all is cleared away the crew secure the tube to the ball or diaphragm, clear away the securing bars, remove the safety pin from the locking lever, and place the training pinion into gear. The tube is then trained to the loading position and the door opened. When that is done the crew fall out and provide the torpedo. The officer in charge then gives the orders for impulse and range; for instance, thus: "Four ounces impulse, 400 yards range, ten feet deep, forty yards controlling gear." Thereupon the proper adjustments are made, the torpedo is charged, propellors are seen to, the pistol is fitted, and the Holme's light (if at practice) fixed to the head. The order is then given to "launch in," when the torpedo is gently launched into the tube, particular care being taken that it enters correctly, the "stop valve" having been previously opened. When the tail is inside the tube, the clamps are taken off the propellers and the door closed. If air impulse is used the firing reservoir is charged, and if powder impulse, the cartridge is inserted in the pocket. The tube being now charged the officer gives the necessary orders for training and elevation, and the tube is directed accordingly. At the order "stand by" the port is raised, the electro magnet is examined and seen to be in proper working order, the safety pin of the firing lever is removed, and the slot and bolt for the electric circuit connected.

When the proper moment arrives the torpedo is fired by pressing the electric key. The safety pin of the firing lever is then replaced, the tube trained to the loading position, and the door opened for the reception, if necessary, of another torpedo. Similarly, different duties are allocated to the crew for the work of returning the torpedo and securing up again.

The foregoing is of course only a general description of the drill for an above-water tube. In the drill book the duties of each man in the crew are clearly set forth so that there shall, as in gun drill, be no bungling or omission of any single part of the work. The same remark applies to all the many and various drills connected with the working of torpedoes and tubes. The drills take place every Friday, which is the day in the navy for "general quarters" drill, and also on any occasion that the captain or torpedo lieutenant may think fit.

Torpedo Depôts.

The chief naval store-house for Whitehead torpedoes is situated at Portsmouth. Home sub-depôts are also kept at Devonport, Chatham, and Sheerness, the latter being simply an overflow for Chatham and subordinate to it. There are also subsidiary depôts abroad at Malta, Hong Kong, Gibraltar, Cape of Good Hope, Bermuda, Halifax, Esquimalt, Bombay, and Sydney. Devonport and Chatham have about 350 and 400 torpedoes respectively in store; and at the subsidiary depôts abroad, the number varies from 20 to 100 according to the value and importance of the station. Altogether there are about 4,000 *serviceable torpedoes* in the Service, and this number is being gradually augmented.

The store-houses at Portsmouth, which contain about 950 torpedoes, are the largest of all, and the whole construction and management of this establishment may be said to be on a scale commensurate with its importance. The careful precision and scrupulous cleanliness which mark the well-conducted man-of-war is found ashore here in an even still more accentuated form, and the condition of the whole place reflects the greatest credit on the Engineer officer who presides over it.

The general arrangement of the store-rooms themselves can be clearly understood on reference to the accompanying photograph, which gives a view of one of them. The torpedoes are placed in different stacks, the ships to which they severally belong being plainly marked by a tally board surmounting them. Those torpedoes which are either not yet allocated to any particular ship, or are of such a pattern that for ordinary purposes are considered obsolete, are carefully marked with their pattern number. When a ship is in reserve or out of commission, her torpedoes are not left to the tender mercies of dockyard "maties," or prying strangers, but are returned into the store, carefully overhauled and corrected, and then stacked together so as to be instantly handy when required. Torpedoes when they arrive from the manufacturing shops are packed in stout wooden packing-cases, but, as will be seen, they are not kept stored in this condition, as it is extremely necessary that they be kept under close observation. They are simply kept covered with a thin layer of oil to keep out rust, and by a new arrangement, canvas coverings are placed over the engine compartments to keep out dust and dirt. Those torpedoes fitted for submerged tubes also have their secret fittings screened with canvas.

When the torpedoes are returned into store from a ship —and this rule also applies to all stored torpedoes from

Fig. 17.—Interior of a Store-Room at Torpedo Depôt.

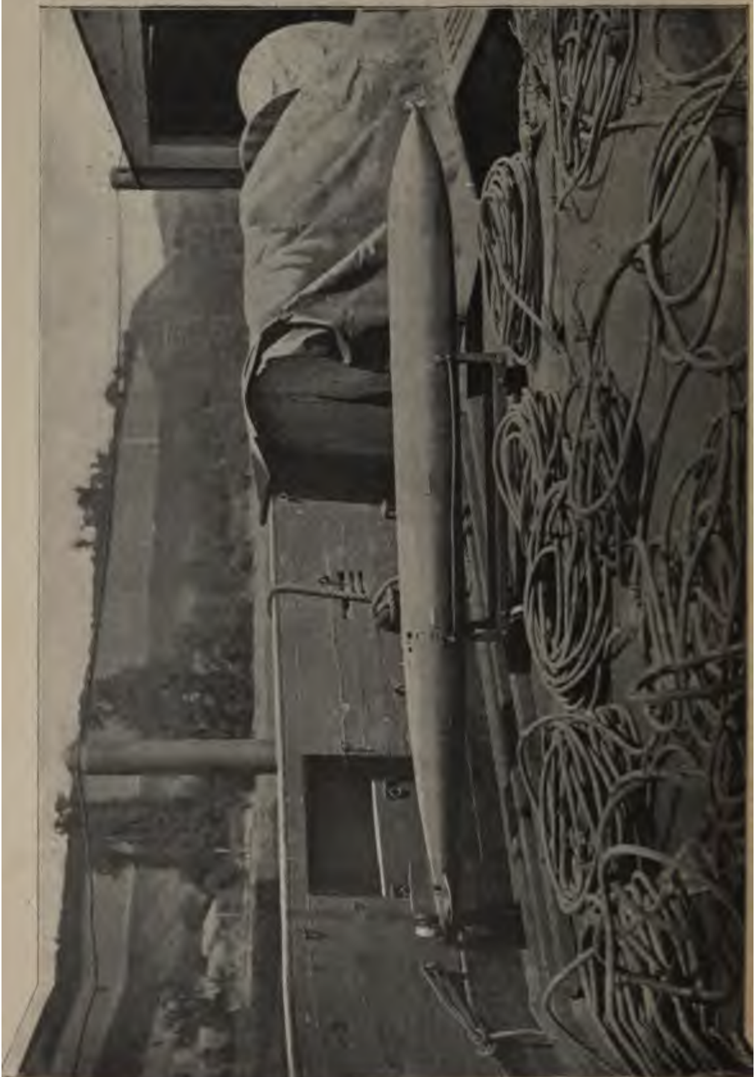
time to time—they are taken to pieces, all parts are thoroughly examined, tested, and re-adjusted, and the particulars inserted in the history sheets. Such an important work requires a large and highly qualified staff of officers and mechanics, and, indeed, so heavy is the work now that the greatest difficulty is often experienced in properly coping with it. It is true that the Admiralty have at last, after many years of hesitation, finally decided on the destruction of a number of the most antiquated patterns, the constant tinkering and adjustment of which proved more expensive than actually buying efficient ones of the latest type. This clearance of rubbish will relieve the work in the stores for a time but not for long, for Whitehead and Woolwich are sending in supplies every month. Not only have the torpedoes to be kept in proper repair, but it is the business of the torpedo depôt staff to fit them with all the latest improvements and adjustments as far as their original construction will allow. Adjoining the repairing shops is a separate room which is occupied by mechanics belonging to the Woolwich manufactory. These men make the final adjustments to the torpedoes made at that place, and turn them over complete to the Staff-Engineer in charge of the depôt, who represents the Admiralty. The passage of a torpedo through the door connecting the two rooms marks its entry into the Navy.

Besides the repairing shops there are rooms fitted up with diagrams and models by which the torpedo artificers and Engineer officers are taught the anatomy and working of the Whitehead. The models are beautifully made, and are far better than any to be found in the *Vernon* or *Defiance*; and in connection with this it almost seems a pity that the executive line do not go through this excellent school. Next to the class rooms are the store rooms where are stowed all the different tools, spare parts, stores, etc.,

belonging or appertaining to the Whitehead torpedoes. These stores are kept in a manner which is almost ludicrous in its exactitude. Every pattern of tool, bolt, pin, screw, spanner, wheel, cog, socket, or plate belonging to torpedoes has its own separate locker, and every item is carefully numbered and accounted for. As an example of the care with which the stores are kept it may be mentioned that a particular tiny pattern of brass screw which forms part of the torpedo's mechanism, and which is valued at about 2½*d.* per gross, is never allowed to be a single number wrong. On one occasion when the stocktaking took place, it was found that, instead of 5,000 little screws being accounted for by the man who was told off to count them, there were only 4,997! Several foolscap letters were written and exchanged over those three little screws, though their value was not more than a small fraction of a farthing. Better, however, to be too careful than too slack about such important stores as these. In any case the excellent manner in which they are kept is a proof of the soundness of their arrangement.

The torpedoes, as has been already explained, are constructed at Mr. Whitehead's works at Portland, at Woolwich, and at Messrs. Greenwood and Batley's, of Leeds. The work of each is uniformly good, though there is a certain disadvantage in having more than one manufactory—namely, the difficulty in making the different parts of torpedoes made in different shops interchangeable. Although every effort is used to keep to exact measurements it sometimes happens that discrepancies occur, with resultant confusion and inconvenience. On the other hand the advantage of having more than one source of supply during the stress of war more than compensates for such a drawback.

In conclusion, it may be mentioned that experiments are being carried out with a view to discovering the deteriora-



tion of torpedoes if kept on board a ship in reserve. The advantage of such an arrangement however would appear somewhat doubtful.

In addition to the duties already described, the Staff Engineer in charge of a depôt is responsible for the distribution of all torpedoes for sub-depôts and all correspondence relating to the torpedo service stores. The spare torpedo tubes do not come under the control of this officer's department, the dockyard people having this important duty assigned to them. The manufacture and store of submerged tubes also come under the control of the dockyard.

West & Son

FIG. 19.—STEAMBOAT FIRING SPAR TORPEDO.

CHAPTER V

THE SPAR, BRENNAN, AND OTHER TORPEDOES

THE SPAR TORPEDO

THE Spar torpedo is the simplest form of torpedo in use in the Navy, though its advantage in this respect is more than counterbalanced by the extreme danger which its use entails on the operator. It is a survival of the old original form of torpedo, and until a modern naval war takes place, and its impracticability is finally demonstrated, it will continue to receive a certain amount of respect and attention, if only for the fact that it can claim to have done more effective work in warfare than any torpedo which has yet been used—that is of course excluding mines.

The Spar torpedo accomplished a considerable amount of execution during the American Civil War, and later in the war between France and China in 1884. Its success in both cases, however, may be said to have been due to the same cause, namely, the weakness or supineness of the enemy. In the American War it was due to the former cause, and in the latter war to both. In the days of the American Civil War the vessels which were attacked had not the advantage of quick-firing guns or torpedo nets, and

the consequence was that those who used the Spar torpedo were able to bring their weapon close up to the side of the enemy without running a very exceptional amount of risk. In the China War the French found the crews of the Chinese vessels either fools or cowards, if they were not asleep, the result being that the effects of the Spar torpedoes on their ships were destructive in the extreme; far more so than in the American War, for the torpedo in the meantime had been greatly improved, as, for instance, in the substitution of guncotton for gunpowder.

In fact the guiding principle of the Spar torpedo is that its construction and design render it necessary that wherever the torpedo goes the operators must go too. When it is exploded against a ship's bottom, the people operating it are only a few feet off, and are consequently placed in the most dangerous position possible. Nowadays it would be almost impossible for a steamboat to steam alongside a wakeful enemy and coolly point the nose of a torpedo against her water-line; for should a vessel have the temerity to attempt such a thing, she would, unless the whole enemy's crew were asleep, be received with an overwhelming storm of lead and steel from the quick-firing and machine guns, and would stand little or no chance of approaching within effective distance. Had modern naval ordnance not improved since torpedoes were first invented, there would have been little need for such delicate and wonderful weapons as Whiteheads or Brennans; but now that war vessels bristle with guns which can fire hundreds upon hundreds of shots a minute, it is necessary to give them as wide a berth as possible, and to strive after long ranges under water as well as above. It is, however, just on this particular point that the Spar torpedo fails, for it has practically no range at all. However, as has *been* pointed out, under certain circumstances this

particular form of torpedo can be turned to effective use, and at any rate it is inconceivable that if there was not something to commend it in the eyes of our naval officers it would be retained in the navy a single day longer. Probably the purpose intended for it in the next naval war will be the blowing-up of booms which have been stretched against the entrances to harbours, torpedo-nets, mooring buoys, and comparatively unprotected vessels. It has at any rate the merit of being exceedingly destructive

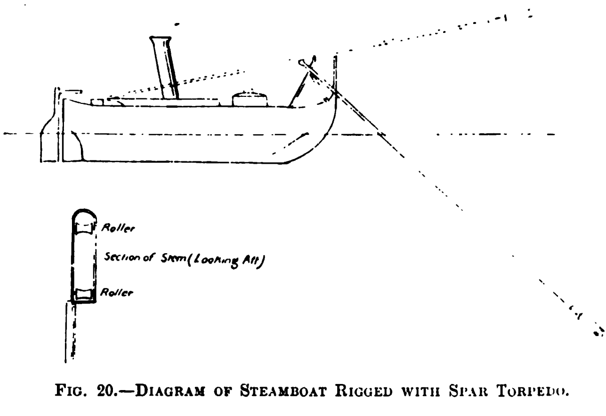


FIG. 20.—DIAGRAM OF STEAMBOAT RIGGED WITH SPAR TORPEDO.

when once it has been got home, and its usefulness may be greatly enhanced by the skill and daring of the men who handle it.

The following is a description of a spar or outrigger torpedo such as is supplied to a 38 or 48 feet steam pinnace.

Six stout spars are supplied, each with a length of 42 feet, and a diameter of 6 inches tapering to 5 inches at the forward end. One spar is used at a time. The spar is

laid fore and aft the boat, and its foremost end is raised. About 6 feet abaft the boat's stem is placed an iron frame consisting of two upright bars, 8 inches apart, pivoted at their lower ends and joined by a cross roller on top, a few inches below which another roller is fixed with its axle also supported by the two upright bars. The spar is then rested on the lower roller with the cross roller above it. On the stem of the boat is another similar frame, but fixed with two rollers (see diagram of stem), the lower roller being placed at the bottom of the frame, and the spar is made to go between them also. The after end of the spar rests right astern, and has two purchases made fast

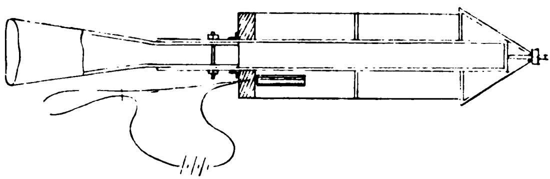


FIG. 21.—THE SPAR TORPEDO.

to it, one leading forward, the other aft. The end of the spar is then fitted with the torpedo. The latter consists of two iron canisters filled with guncotton and closed at both ends. Running through the centre of each is a cylindrical hole for the purpose of receiving the iron-shod end of the spar. Another hole is also provided in the after end of the canister for the reception of the primer tin. The canisters are kept in their place on the end of the spar by a conical-shaped block of wood which is screwed down tight on to the foremost end of the other canister, the conical shape being given so as to allow as little resistance as possible to the water. The wires leading to the detonator within the primer are rove through a hole in

the after end of the canister and brought to the battens in the boat.

The spar and torpedo are now ready fitted, and lie in the position indicated by the dotted line in the diagram, the spar being rigged right in, and its torpedo end elevated in the air. When the order "Rig out" is given, the purchase, leading forward from the after end of the spar, is manned, and the latter is launched forward until the increasing weight outward, tilts it downward. There is no tendency, on account of buoyancy, for the torpedo to remain on the surface, for the pressure of water forces it down until the spar is right out, and lies in the second position in the diagram. If the boat is going at a high speed the strain on the rollers of the inner frame is very great indeed, as also it is on the spar itself, and in consequence of this it is not launched out until the very last moment. All is now ready for action, and directly the torpedo is on the point of bearing against the object aimed at, the engines of the boat are put at full speed astern, and the firing key of the battery is pressed result, explosion. What remains of the shattered spar is then rigged in, and another one with torpedo attached is, if necessary, supplied in its place.

The proper service charge for a Spar torpedo consists of two 16½ pound tins of wet guncotton with one primer of 2½ pounds of dry guncotton in the primer tin. A three cells boat's firing-battery is used for firing. The length and inclination of the spar previous to firing is so arranged that the torpedo remains at a depth of at least 10 feet below the surface, and its least horizontal distance from the boat must be 33 feet.

As might be expected, the greatest precautions have to be taken for reliable firing and against any possibility of the charge exploding when suspended in the air previous to

rigging out. In the first place, prior to filling the torpedo, the primer tin is tested by being submerged for an hour in deep water, and the detonators are thoroughly examined. If the tin is dry after submersion it is ready for filling. The detonators are charged with fulminate of mercury, and consequently require uncommonly careful handling whilst being inserted into the primer. The boat's battery is tested by making it fire four drill tubes in fork through the circuit.

When the boat is prepared to leave the ship it is shoved off clear without the firing battery on board. The spar is then rigged out, the circuit tested for continuity, and the spar rigged in again. All being satisfactory, the boat comes alongside the ship, and the battery is fixed on board. The boat then proceeds on her mission, and every one on board prepares her for the coming shock. The fires are carefully looked to, and the furnace doors shut, the gauge glasses covered, and cocks shut off so as to prevent any risk of explosion and scalding. Every one then gets under cover, and perfect silence is maintained. On approaching the enemy to within about 60 yards, the order is given to "rig out," and the crew handle the spar in the manner already explained. According to the advice generally laid down, it is best to approach the enemy on the bow or stern, and explode the torpedo as near her centre as possible. In any case every effort should be made to deal the blow somewhere in the region of the engine-rooms or shafting, so that even if the ship's water-tight compartments enable her to keep afloat, she will be totally disabled on account of her engines being thrown out of line by the force of the explosion. When the spar begins to crack, and not till then, the firing key of the battery should be pressed and the charge exploded.

Dreadful accidents have sometimes happened through the battery ends of the conducting wires accidentally coming into contact with the battery before "rigging out," when of course the torpedo explodes in mid air. In action, the greatest obstacle to guard against is detection by the enemy's search-light, and consequently every boat running spar torpedoes is painted black, and the same is done to her fittings, the men's faces and hands, &c., before making an attack at night.

Before concluding this description of the Spar torpedo, reference must be made to another mode of using it, different to that already described. When the boat is capable of steaming over 9 or 10 knots, it is of course essential that every advantage should be taken of her efficiency in this respect, for rapid approach and departure counts for everything in Spar torpedo attacks. Yet if the spar be rigged out in a fast boat in the manner shown, it would almost certainly snap, or even if it did not, the boat's way would be very considerably impeded by the resistance of the spar to the water. Accordingly what is called a "swinging" outrigger is substituted for the other arrangement. It consists of a long spar pivoted on deck right aft, with its head resting on a "slider." The torpedo is made fast to the head in the ordinary way. The boat on approaching the enemy passes up to within about forty feet of him, and as she rushes past, the head of the spar is slipped overboard. As it catches the water and swings aft, the torpedo on the head is brought against the enemy's side, and the charge is exploded. To prevent any possibility of the charge being exploded by accident or in the hurry of the moment before it has swung away well clear of the boat, an automatic circuit breaker is fitted, which prevents it being fired until the spar has reached a certain angle away from the boat's side.

If the chances in favour of a Spar torpedo attack proving successful are few, there is at least always this advantage, namely, that in the event of it being ineffective the loss of life will be exceedingly small. Judging war as a game of units the risk of a few lives is perhaps well worth the chance of sinking an ironclad with several hundred souls on board. In a Spar torpedo attack you can lose but little; you may gain much.

The Brennan Torpedo.

In a book such as this, dealing as it does with a particular branch of naval science, it is perhaps superogatory to refer to a weapon with which the Navy has no concern. The Brennan torpedo, though a maritime weapon, is under the entire direction and control of the military authorities, and its method of construction and mode of working forms therefore no part of a naval officer's curriculum. The author consequently may be forgiven if he approaches the subject with a certain amount of diffidence and indecision, for whereas the Whitehead no longer possesses any secrets, at least so far as its actual construction is concerned, the anatomy of a Brennan torpedo is still kept screened from the vulgar gaze, and no one except those specially deputed to look after it, and perchance the foreign attachés, know more than an outline of the principles governing its construction. Still, the little that is publicly known is extremely interesting, for the Brennan torpedo possesses three especial claims on our curiosity. It has cost the country over £150,000, it constitutes a most effective protection to many of our important harbours and channels, and its construction in face of its undoubted wonderful performances is evidently a product of high engineering and mechanical skill.

Mr. Brennan, the inventor, who is still quite a young man, was a watchmaker in Melbourne when the idea of the torpedo, absolutely new and original, occurred to him. He was not in a position to work out his invention and bear the cost of models and experiments alone, so he associated himself with a fellow citizen who from time to time provided him with the necessary funds for giving solid form to his idea. One of the professors at Melbourne University to whom he was introduced took great interest in the matter, and not only rendered him valuable assistance in the way of calculations, but also enabled him to bring his torpedo under the notice of the Colonial Government. Grants of public money were made towards its manufacture and development, and it was eventually experimented with and approved of by the principal military and scientific authorities of Victoria. Communications were then opened with the Home Government, and pending the result of these it was decided not to exhibit the torpedo at the Melbourne Exhibition. In November, 1880, our Admiralty directed the late Rear-Admiral J. C. Wilson, then Commodore on the Australian Station, to report to them as to the merits of the invention. He thereupon ordered a committee of four officers belonging to his squadron—a commander, two lieutenants, and a chief engineer—to examine and report on it. Their verdict was so favourable that early in the ensuing year Mr. Brennan and his torpedo were ordered to England, where they have been ever since. It was very soon made clear that the principal, if not the only, use of the weapon would be for the defence of creeks and harbours. So the whole concern was handed over by the Admiralty to the Royal Engineers at Chatham. By their advice in 1882 Mr. Brennan was paid a retaining fee of £5,000 and engaged for three years at a salary of £2,000 a year and expenses,

for which he was to give his whole services to the improvement and development of his invention. It was afterwards settled that he was to receive a reward of £110,000 and a salary of £1,500 for five years.

The original Brennan torpedo, in 1877, was different in many ways to that ultimately improved and adapted by the Chatham officers ten years later. The principles of its construction, a description of which, together with the diagrams, the author is indebted to the proprietors of *Engineering* for, may be briefly summarised as follows:— Its motive power is external, and not contained, as in the case of the Whitehead, within the torpedo itself. To propel it through the water a separate engine capable of working up to 100 indicated horse-power is used. This engine drives two large drums at a high velocity, which wind in two fine but strong steel wires, similar to those used in a piano, but thicker. The two other ends of the wires are wound round two small drums A and B inside the torpedo, and the action of winding up the wires on the engine causes two small wires within the torpedo to unwind at a very high velocity. The torpedo reels are connected to two propeller shafts and work in opposite directions, the propellers also working in the same manner as in the Whitehead. The result is that the harder the wires are hauled in by the engine, the quicker the propellers in the torpedo revolve, and consequently the faster the latter goes; or in other words the more the torpedo is pulled back the speedier it travels forward. The most ingenious part of the torpedo however is the steering apparatus whereby it is kept entirely under the control of the operator from the time it is launched until it strikes the enemy, or returns to its station. It can be made to twist and turn about in any direction within an arc of 40° each side of right-ahead. It cannot however return of its own accord to its station,

and after exercise has to be towed back home by a boat. The arrangement of the steering apparatus is, or rather was until lately, as follows:—

On the inner solid propeller shaft, S, is cut a screw thread, and immediately over it is a longitudinal slot cut in the outer hollow propeller shaft, S′. A collar, N, with an internal screw-thread fits on to the hollow shaft and lies in the slot. Cut on the outside of this collar is a deep groove in which work two studs on the end of a forked lever, L. This forked lever joins up to a second fore and aft lever, L′, connected to the quadrant of the rudder shaft, the result being that any movement backwards or forwards of the collar N will be transmitted by the levers to the rudder. Now as long as the speed of the outer and inner propeller shafts remains equal, the collar N with its internal thread and the thread on the outside of the inner shaft which engage, will revolve around together without any shifting of the collar N. But directly the shafts begin to revolve at different speeds the collar N will begin to travel backwards or forwards, according to whether the

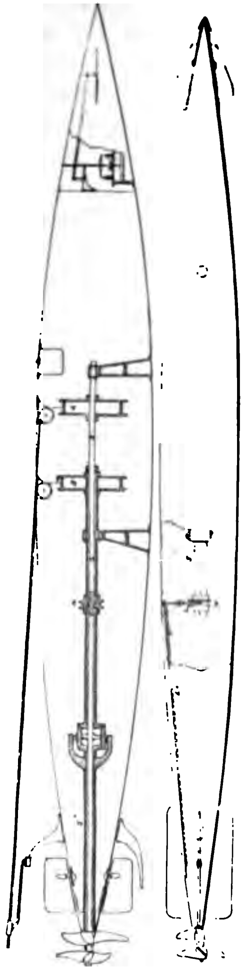


Fig. 22.—The Brennan Torpedo.

inner shaft is revolving slower or quicker than the outer. Thus the rudder can be moved at will by simply making a difference in the speed of the two drums on the engine.

The mechanism for preserving the Brennan torpedo at a fixed and regular depth in the water during its run bears a striking resemblance to that already described in the Whitehead. With this difference however, namely, that in the Brennan the horizontal rudders are placed right forward instead of aft, and the steering apparatus works directly on the rudders, instead of through the medium of a servo-motor as in the case of the Whitehead. The torpedo is also steadied by fixed horizontal fins placed on each side and just forward of the propellers. The steering apparatus consists of a pendulum weight and a hydrostatic valve. The two actions combine in much the same way as in the balance chamber of the Whitehead, and there being no long lead to the rudders, the direct effect of the mechanism on them is sufficiently strong. The hydrostatic valve is of course adjusted to whatever depth the torpedo is required to run at.

The engines consist of two drums, driven by a pair of direct high-pressure engines at a high speed. The working parts of the engine are carefully protected from the wires leading from the drums, so as to prevent any risk of entanglement. The engines are fitted with valve gear which can be reversed or linked up so as to work expansively, and the steam is admitted to the engines by a common valve. The drums run loose on the shafting and are connected by a "jack-in-the-box" arrangement by which their respective speeds can be regulated by means of a foot-brake without altering the speed of the engines, and the apparatus is so contrived that in proportion as the speed of one drum decreases the other increases.

The charge is composed of gun-cotton and a primer, and

is placed in the head of the torpedo. Its weight is about 200 lbs., or enough to send to the bottom the strongest ship ever constructed. The path of the torpedo is made known to the operator by a cloud of smoke which is emitted from the Holmes's light fixed on its nose, and at night by the flames rising from the same to the surface of the water.

Taken altogether there can be no doubt that the Brennan torpedo is a most useful weapon for the defence of narrow channels or entrances to harbours. At the western entrance to the Solent, for instance, there is one stationed which may be trusted to reach any enemy's ship which might venture to enter there. Under such circumstances it is far more formidable than the Whitehead, being more reliable in its working, and able to render any attempt at evading it, by quick manœuvring, almost out of the question. On the other hand, unless radical alterations are made in its size and mode of working, it is obviously quite unsuitable for naval uses, unless the ship operating it happens to be at anchor.

Other Torpedoes.

Although the Whitehead, Brennan, and Spar torpedoes are the only types in use in this country a brief reference to a few of the more notable kinds in use in past and present times in other services will be of interest. It would be utterly impossible however in a book of this size to do more than touch upon a few of the numberless inventions in this direction which have been brought out during the past twenty years. Most of these ideas are crude and unworkable, but a certain number of them have borne the test of actual experiment, and so therefore merit at least a *passing notice.*

First and foremost amongst the miscellaneous torpedoes is that known as the *Schwartzkopff.* There are actually a few in our own navy, but the chief adopters of the weapon are the Germans and Japanese. It differs but slightly from the Whitehead, except in one important particular. It is made of a special material called phosphor-bronze, the composition of which is kept a secret. The chief advantage of the metal is its immunity from rust. It is manufactured at Messrs. Schwartzkopff's works at Berlin.

Next in importance and ingenuity comes the *Howell* torpedo, the form adopted by the United States Government. Its principle of action is as curious as it is ingenious. The torpedo is made of thin steel, and is divided into five sections. The pistol and explosive charge are placed in the two foremost ones, and the third compartment contains the propelling apparatus. The fourth compartment is the buoyancy chamber, and the after one contains the steering mechanism for the horizontal and vertical rudders. The motive power is supplied in the following manner. A large heavy flywheel is placed in the third compartment, and to this is connected a system of bevelled gearing, which transmits a rotary motion to two propeller shafts leading to the stern of the torpedo. This flywheel, just prior to the launching of the torpedo, is worked up by a special steam engine on board the ship to a speed of about 150 *revolutions per second,* and the greater the range the higher is the speed to which it is worked up. The weight of the flywheel is about 100 lbs., and it requires but an easy calculation to discover the initial force contained in the torpedo, when launched under such circumstances. The axis of the flywheel is perpendicular to the longitudinal axis of the torpedo, and its position gives it an inherent directive control over the steering of the weapon. Conse-

quently it not only propels the torpedo, but actuates the steering mechanism as well. When the torpedo is launched, the direction in which it lies is the direction of the plane of the revolving flywheel, and the latter therefore exerts a counterbalancing resistance to every tendency to deviate from that path. The peculiar manner of mounting it, and the arrangement of the rudder mechanism allows it to exert that directive tendency on the torpedo so as to keep it always turned in the same direction. As in the Whitehead and Brennan the horizontal rudders are actuated by the combined action of a pendulum and hydrostatic valve. The chief disadvantage in the Howell torpedo is the necessity of applying the motive power up to the very moment of launching. Any violent motion of the ship firing it also tends to destroy the directive power of the flywheel; and the fact that the torpedo cannot be simply left in the tube ready for action at a moment's notice, renders it particularly unsuitable for boat work. If the platform from which it is fired is steady, the behaviour of the torpedo is generally satisfactory, as also is it when the motion of the ship is but slight, for the launching carriage is specially designed to provide, to a certain extent, for this contingency. But taking it altogether the "Howell" is distinctly inferior to the Whitehead in actual running and general handiness, and that the United States Government have recognised this fact is evidenced by their partial adoption, of late, of the Whitehead torpedo.

There are many other auto-mobile torpedoes which, if impracticable, certainly possess the merit of being exceedingly ingenious. One named after Mr. *Peck*, its inventor, is designed so as to substitute steam for compressed air, the steam being supplied to the reservoir from a boiler on board the ship. The steam and water on its passage into the reservoir is still further heated, and the inventor claims

that a torpedo so charged will retain a working pressure for nearly an hour. Another form of auto-mobile torpedo is one driven by liquid compressed carbonic acid, and with a steering apparatus actuated by a magnetic needle—a pretty idea certainly, but rather too complicated and delicate to stand much rough treatment.

Our Brennan has a rival in America in the shape of the *Sims-Edison* torpedo. In fact, the inventors of the latter claim that it is a distinct improvement on the former weapon. An interesting trial was made with it in Stokes Bay on February 15, 1892, before a large number of experts, and foreign attachés, and judging by the results this torpedo constitutes a very formidable weapon for harbour defence. It consists of a copper float shaped somewhat like a canoe with a curved deck on which stand two vertical rods surmounted by balls to show the operator the path of the torpedo. Below this float suspended by three rigid steel stays is the torpedo itself, a hollow copper spindle with tapering ends, made in four sections. In the foremost section is the charge and primer, in the next the coil of electrical cable, then the motor, and in the stern compartment the steering gear, with the propeller astern. Its length is 31 feet and diameter 25 in. The torpedo after being launched into the water is driven by electricity, conveyed to it by a dynamo on the ship or shore, and a secondary battery for the steering apparatus. As the torpedo makes its way through the water the cable runs out of a tube which is fixed under the propeller astern, the length of the cable being about 4,500 yards. The torpedo on being launched generally remains almost stationary in the water for about ten seconds, and then gradually develops a speed of about twenty knots. On the occasion of the trial referred to an attempt was made to demonstrate the suitability of the *torpedo for* ship work. To accomplish this, a large unwieldy

crane was fitted up on board the steamer *Drudge*, and the torpedo was hoisted out and launched when the vessel was crawling along at the rate of about three knots. No decision of any value could therefore be come to regarding the merits of the torpedo when worked from a ship. In any case, the same objections must weigh against the Sims-Edison as with the Brennan. A connecting cable would be most unwieldy at sea, and in a general action between two fleets it would be sheer madness to attempt to use locomotive-controllable torpedoes of such a pattern. Besides, the apparatus required for hoisting out a Sims-Edison torpedo is topheavy enough to capsize any torpedo boat yet built. There is one important particular, however, in which the Sims-Edison shows an improvement over the Brennan. It can twist and turn about in *any* direction, and can if necessary return to its point of departure. If a vessel entering a harbour possessed extreme handiness, she might manage to escape from a Brennan by turning on to a course which that weapon could not follow. With the Sims-Edison, however, no such evasion would be possible. On the other hand, the Brennan is completely submerged during its run, whereas the Sims-Edison has its supporting float exposed; and if that should be hit or torn by shot the torpedo it supported would stand little chance of remaining effective much longer. In short, the great question as to whether the Brennan or the Sims-Edison is the more effective weapon can only be finally decided by the carrying out of exhaustive comparative trials—an unlikely event to happen.

Amongst other notable torpedoes are the *Maxim* (locomotive) and the *Lay* and *Nordenfelt* (auto-mobile). The Lay torpedo is specially interesting from the fact that it was used by the Peruvians in their war with Chili in 1880. It was not successful, however, owing chiefly to the ignorance of its

users. The peculiarity of the Nordenfelt is that its motive power is self-contained electricity. Mr. Maxim aims at making his torpedo an improvement on the Brennan, and follows the general principles guiding the construction of the latter.

Enough examples have been given of miscellaneous torpedoes to show the vast field of ingenuity and enterprise covered by inventors in their quest for a perfect weapon. We shall have to wait a long time probably before anything can be found to eclipse the beautiful invention of Mr. Whitehead. The cleverest mechanics of Europe and America have tried to solve the problem for the last twenty years, and the man therefore who succeeds where they have failed may well claim to stand in the front rank of the inventors of his day.

CHAPTER VI

TORPEDO NETS, NET CUTTERS, SEARCH-LIGHTS, AND PASSIVE OBSTRUCTIONS

Torpedo Nets

Hitherto we have dealt only with various means adopted for inflicting submarine injury to a ship. We now come to the question as to the best way for the ship to protect herself from such an attack. It may be said at once that no really effective protection from torpedo attack has ever yet been invented, or indeed is ever likely to be. The only serious attempt yet made in this direction consists of an arrangement of nets held out as a sort of crinoline round the ship. This idea was originally the creation of the naval authorities, but the result was a comparative failure, for the booms which held the nets out were large and unwieldy, and were fixed to the ship in such a way that the shock of a discharge was certain to unship them, and they were perfectly impossible to use in any sea way. In the system invented by Mr. Bullivant, however, the nets appear to be better made and the booms slightly lighter and handier.

Mr. Bullivant's idea consists of a number of hollow steel spars 30 feet long, the thickness of the steel being about $\frac{6}{16}$ of an inch. They are placed at a distance of

about 45 feet from one another all round the ship and pivoted to her side. The pivot consists of an iron ring and bolt at the inner end of the spar, fitting into a steel socket riveted on to the ship's side and fixed there by a screw nut underneath. The jackstays on which the nets are slung are shackled to the boom ends by spectacle eyes. There are two standing lifts for each boom, so as to provide for one being shot away. When both are intact, one of them can be used as a spare guy. A wire rope is also attached to the bottom of each net, passed through several meshes and led inboard; it is used for the purpose of lifting up the foot of the net and taking the weight of it when necessary. The nets are secured to a stout jackstay suspended from boom to boom, and are lashed to one another by stout wire lashings. Each net consists of a mesh of steel wire grummets six inches in diameter, connected by galvanised steel rings, and measuring 20 feet by 15 feet. The grummets are made of the finest steel and thickly galvanised. Each net weighs about 400 lbs. A piece of heavy chain is fitted to the foot of each net so as to ensure it keeping as upright as possible when under way or in a current.

The net defence of a ship is nearly always divided into three different parts, namely—the "main defence," "bow defence," and "stern defence." The "main defence" covers the middle and most vital parts of the vessel, that is to say, the engines and magazines, and the "bow and stern defences" cover the other parts of the ship. These latter, however, are only used when the ship is at anchor.

As may be expected, however, the handling and fixing of these nets even in harbour and during the finest of weathers is an exceedingly heavy business. Rigging net defence, nevertheless, serves one useful purpose, at any rate, namely, *that of* a violent form of exercise for ships' crews who are

deprived of sail and spar drills by the advent of mastless ships into the navy. Commanding officers nowadays are often at their wits' ends how to provide healthy exercise for their men, and consequently torpedo nets have been receiving more attention than their actual usefulness merits.

Although torpedo nets are still looked upon with favour by a large number of officers, there are, on the other hand, many who utterly condemn them. A writer in the *Globe*, whose position as an expert on these matters entitles him to give an opinion on the subject, says:—

"This style of defence, if used in ships of Her Majesty's Navy, is indeed a defence, not, however, of our own ships, but of those of any enemy with whom we may at that time be at war; for not only are they useless as a protection against the torpedo itself, the cutter having quite mastered the net, but are in themselves, under almost every circumstance, an absolute detriment to the ship using them.

"The fact that the net cutter has by practical experiment proved its efficiency against the present form of net would, one might have thought, led to the abandonment of this cumbersome and useless (even from its own point of view) form of defence. We will, however, go beyond this, and on the supposition that nets much heavier, section for section, of course, than the present pattern, have been manufactured quite invulnerable to the attack of any cutter that could be produced, and at least thirty feet deep. We will proceed to review the probable effect on the ship using them:—

"I.—Ship not disabled.

"(*a*) AT SEA.—Impossible.

"(*b*) AT ANCHOR.—Detrimental to efficiency, for they would most materially hamper the very necessary ability "to slip" and proceed to sea at short notice, and in a large number of ships would, when topped, mask several guns and the above-water torpedo discharge; indeed, an efficient ship lying at anchor has no need of nets, and to rig the defence is simply work done for no practical purpose, since on sighting an enemy the very first evolution will be to get under way, which of itself necessitates the getting in of this defence, and a ship caught at anchor is in all probability a ship lost, with which nets as a "defence" will have nothing to do.

"II.—Ship disabled at sea, at anchor, or an efficient ship surprised at anchor with her nets out.

"(*a*) Attack by Ships.—Nets will not protect the ship in either case from being rammed; indeed, they will assist it, since you are by your nets disabled as regards using your above-water torpedo armament, and if you partially unfurl your nets to unmask the submerged tubes, you lay yourself open to the very attack that you are in other parts defending yourself from; the enemy can close and ram on any bearing least protected by gun fire.

"(*b*) Attack by Boats.—A boat is quite able to place a torpedo over the net, the pistol being rendered dangerous beforehand, and this would undoubtedly be done in any determined attack by, say, two or three boats on a net-protected ship.

"To sum up, therefore, nets are only useful in that they compel 'boats' when attacking to close right in, which should be feasible under ordinary circumstances and a certainty if the number of boats in a simultaneous attack exceeds the number of search-lights in the ship attacked."

Advocates of net defence will have considerable difficulty in contesting such a verdict as this; yet it is hardly likely that this only form of defence against torpedoes will be lightly thrown aside. Even the writer of the above remarks would probably prefer to eat his dinner, in war time, behind torpedo nets than otherwise. After all, the question of their usefulness can only be decided finally by actual warfare.

Net Cutters.

Directly torpedo nets came to be adopted as a means of defence against torpedoes, several officers set to work to discover how to enable the torpedo to pierce them in such a way as to allow it to pass through without prematurely exploding. The most successful "net cutter" yet invented is that of Rear-Admiral Wilson. The construction of the Wilson net cutter is very properly kept a profound secret; but it may be stated that it is thoroughly capable of doing

the work for which it is intended, and the toughest and heaviest nets ever yet made have been unable to keep out torpedoes fitted with it. The cutter is attached to the nose of the torpedo, and consists of a scissor-like arrangement. The French have also a net cutter but not so good as ours. The Italian pattern has proved a failure.

SEARCH-LIGHTS.

Although search-lights are not used for the sole purpose of disclosing the approach of torpedo craft at night, yet there can be no doubt that in war time their chief usefulness would be found in this connection. Consequently, any book which professed to deal with the science of torpedoes would be incomplete without some reference to them. Indeed, their working and control is always under the torpedo lieutenant and his myrmidons, who, it must be remembered, are also the "electricians" of the ship.

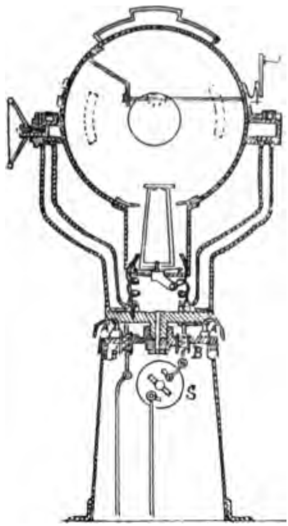


FIG. 23.—SEARCH-LIGHT PROJECTOR

The accompanying diagram is a section of a search-light projector such as is carried on board a ship. The wires communicating from the dynamos below lead up through the pedestal on which the projector stands, one of the wires passing by a switch S on the pedestal. Round the top of the latter are fitted rollers, A A′, on

which rests the bottom plate of the projector. The two wires lead up through two holes in the top of the pedestal and are connected by spring contacts, B, B′, against two circuit rings in the base of the projector one inside the other. Wires again bend from these rings to the carbon holders above. The result of this arrangement is that the projector can be turned about in any direction without breaking the circuit. All search-lights on board ship work with 100 ampères of current, and the voltage at the terminals is about 50 volts. The dynamo should be run at about 80 volts, 30 volts being absorbed by the resistance.

A concave mirror is fitted to the back of the inside of the projector, and the carbons are so placed before it that it reflects a perfectly straight beam of light. The front of the projector is closed with a glass door, though divergent lenses are supplied as well to ships, to be used instead if necessary. A curious point about the search-light is that it is not a *direct* light, but a *reflected* light. The carbons are screened in front by a metal disc, and if the light be looked right into from the front the arc cannot be seen, but only the reflected light from the mirror at the back.

To burn the lamp, the dynamo is started and worked up to the proper voltage; then with the carbons separated, the search-light circuit on the switch board below, and the switch on the pedestal, are switched on. The carbons are then gradually closed, the operator viewing them through a coloured glass prism in the side of the projector. As soon as the carbons touch they are gradually separated again, but only slightly, when immediately their points become heated to dazzling whiteness, the positive carbon forming a little "crater" at its end, and the negative becoming pointed. If the light is burning properly a hissing noise is heard at first, which gradually merges into a higher pitch and finally ceases altogether. The lamp is

focussed by moving the carbons nearer or further from the mirror, and when correct the beam of light will be perfectly true and parallel.

Search-lights are also carried on board torpedo boats, and sometimes picket boats. They are of a smaller pattern than those supplied to ships, and work with only 60 ampères of current. Occasion, also, often arises when it is found necessary to burn search-lights away from the ship; as, for instance, at the mouth of a protected harbour, or at a look-out station on shore. For such cases a special cable is supplied to each ship capable of standing 100 ampères of current. If the distance of the search-light from the ship is less than 500 yards a return cable is used; but if a longer distance, an "earth plate" is substituted. The cable is run off a reel, and carefully protected from being perforated by rocks and sharp projections.

In most English ships the search-lights are placed in a comparatively exposed position, though in action, during the daytime, they would of course be unshipped and stowed away below. The Italians and other foreigners have a very neat fitting for their search-lights between decks. The projectors are of small dimensions and are supported on swinging brackets, hinged just inside the gunports of the battery. When the light is required for use it is swung round so that it can be directed through the port; when finished with, it is drawn back under the protection of the armoured side.

The best way to protect a ship or boat from the rays of a search-light is to paint it a dull neutral tint. There is considerable divergence of opinion regarding the most suitable colour for the purpose. Black, drab, muddy brown, slate colour, and "neutral" tint have each been adapted by different officers at one time or another, and though a considerable number of experiments have been carried

out with a view of discerning the most "invisible" colour the question is still very much an open one. One thing, however appears certain, and that is that the vessel must be painted all one colour, and every bit of white paint and bright-work carefully hidden. The result is that torpedo craft are always exceedingly dingy-looking, and altogether wanting in smart appearance.

There is also considerable difference of opinion regarding the usefulness or otherwise of search-lights. It is claimed by some that the lights only serve to make the vessel using them an easier target for the enemy, and that the glare of the light blinds its users to all surrounding objects. On the other hand the dazzling brightness of the light can be used with great effect against opposing forts. For instance, during an attack on Milford Haven by the fleet during the manœuvres a few years ago, the gunners in the land forts were so blinded by the search-lights on the ships that they were utterly unable to lay their guns at the enemy with any degree of accuracy. In fact when the lights were turned fully on to a gun the sights could not be aligned at all, so completely were the gunners blinded whenever they attempted to look along them. Search-lights are also extremely useful for protecting the entrance to a narrow harbour. By directing the beams of several lights so as to completely cover the water at the entrance it is impossible for any ship or boat to enter unobserved. In the open sea however it is a very different matter, and most captains who were dreading torpedo-boat attack under such circumstances would be strongly tempted to trust to good eyesight and the light of the moon and stars to the dazzling beams of the electric light.

Search-lights are also often used for signalling purposes, either by projecting the beam vertically in the sky and moving it to and fro, or by a system of eclipses and flashes.

In either case the distance at which such signals can be seen on a fine dark night is really wonderful. Cases have been known where ships have signalled to one another over no less a distance than sixty miles.

Passive Obstructions.

Submarine mines are not the only passive weapons used for protecting harbours. Certainly mines are the only things that can be trusted to stop ships from entering, but torpedo boats and other small craft can be effectually kept out by stretching wire hawsers and booms across the entrances. However strongly the latter may be made, though, a heavily-built ship will snap them asunder like pack-thread; and the truth of this was plainly shown a few years ago when the torpedo ram *Polyphemus* forced her way through a boom defence at the entrance to Berehaven. On that occasion it was believed beforehand that the gradual check which the hawsers would give to the ship's progress would bring her up. When the moment of impact arrived, however, instead of stopping the ship, or, as some feared, rising over her bows and sweeping her deck, the hawsers and booms appeared to snap asunder immediately, and the way of the ship was hardly stopped at all.

Yet "boom defence," as it is called, constitutes a very efficient protection against torpedo boats. During the late war between China and Japan the entrance to Wei-hai-Wei was closed with booms and hawsers. Curiously enough the chief usefulness of this boom manifested itself when the disgraceful flight of Chinese torpedo boats took place. So great was the hurry of their commanders to escape from the guns of their own fleet and those of the enemy

that the greater number of them miscalculated the position of the boom "gate," and found themselves hung up on the grapnels of the obstruction, where they were soon pounded to matchwood by the guns of the two fleets.

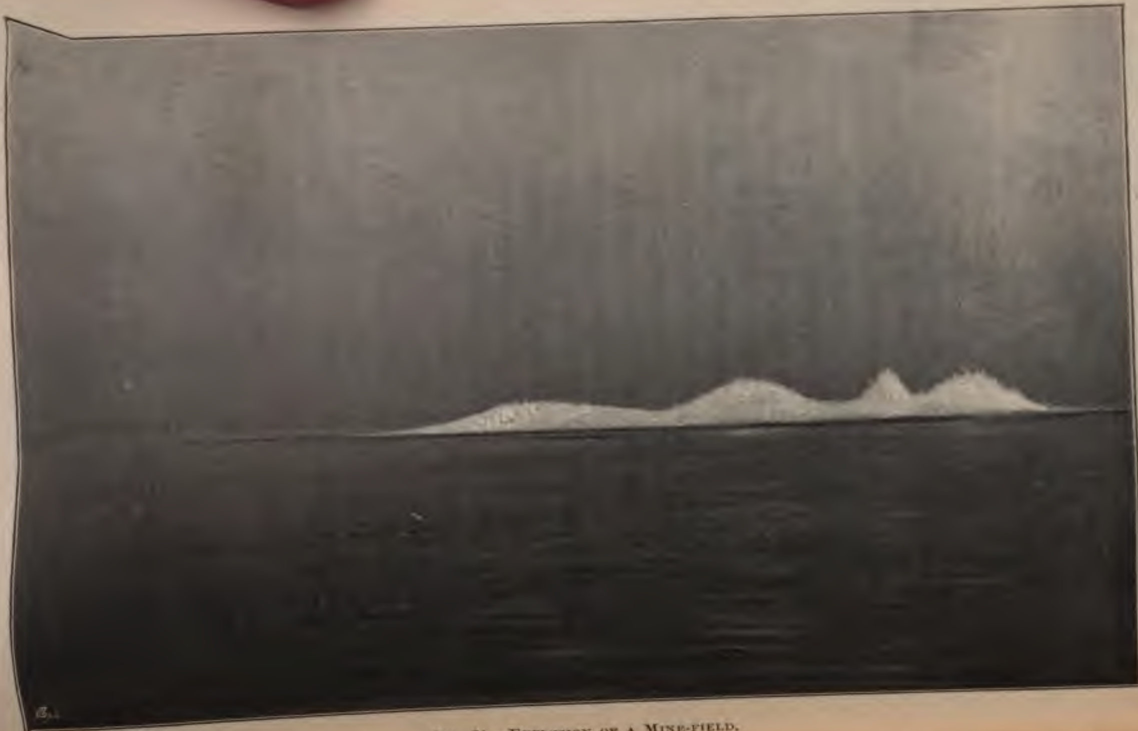
That the authorities at home thoroughly appreciate the usefulness of boom defence is evidenced by their adoption of it in the system of defence of the Medway. The boom is intended to render the river safe from the attacks of hostile torpedo boats, and has taken eight months to put together. It will lie right across the river a short distance above Sheerness near Victoria Pier, and consists of a network of wire hawsers and heavy baulks of timber, which can be submerged or raised into position by means of special apparatus on board the gunboats *Watchful*, *Grappler*, *Mistletoe*, *Bustarer*, and *Firm*. These old gunboats are placed at different intervals along the boom. The boom can be taken to pieces, and stored on shore ready for use when required. Similar booms are also being made at Portsmouth and Devonport, but their construction has been delayed owing to the desire of the authorities to thoroughly test and experiment with the Sheerness one first. The boom is easily put together in a few hours, and of course will never be used except for practice, or when really required for active service.

Amongst other forms of passive obstruction may be mentioned the old, but effectual, method of sinking barges and hulks righ[illegible] fairway of channels. A great deal of trouble t[illegible] can a[illegible]ven by suspending [illegible] the surface so as [illegible] ships passing up [illegible]rk of constructing [illegible] depend very largely [illegible]ders, and the [illegible] found to be [illegible]

There are various ways in which a boom defence can be destroyed. The best, perhaps, is that which consists of an exploding grapnel which can be hooked on to the hawsers. In the grapnel is fitted a large tin of wet gun-cotton with a dry primer and two detonators, connected up to a short cable and battery, or else an ordinary instantaneous fuse. In either case the operators must be careful to stand well clear of the explosion. A special grapnel is supplied in the service for this work. It is fitted with two spring hooks, so that when it is thrown on to the hawser it clings securely to it, and hangs down with the gun-cotton in close contact. The large baulks of timber used in the booms are destroyed by coiling a hose round them filled with discs of gun-cotton or dynamite cartridges. This can be fired either by electricity or instantaneous fuse.

Sometimes the defenders or invaders, as the case may be, are called upon to break the enemy adrift by shattering his anchor cables. In this case a tin of dynamite with primer and detonators is fitted with a long sennit strop, and taken silently and under cover of darkness to the bows of the enemy. When arrived there the strop is passed through one of the links, and a shot made fast to its end. This drags the charge right up into close contact with the cable. The boat then withdraws to a safe distance, and fires the charge by electric cable or fuse. It is better, if possible, to affix the charge just below water, as then the explosion is more violent in its effects.

When torpedo boats or steam picket boats are about to attempt the forcing of a harbour their bows are protected by a slanting stout piece of timber to enable them to slide up and over the boom should they strike it. The propellers should also, as far as possible, be protected with timber, so as to deflect away all passive obstructions.



Symonds & Co.

Fig. 24.—Explosion of a Mine-field.

CHAPTER VII

SUBMARINE MINES

THE science of submarine mining may be divided into two distinct branches, namely, mine laying and mine destroying. In war time, the former work will be carried out by the Royal Engineers on shore and the Navy at sea. The latter work, except in very rare circumstances, will fall exclusively upon the Navy. For whereas mine laying is essentially the work of defenders, mine destroying is, on the other hand, the work of invaders. Both operations call for the greatest skill and care, and in the latter case often considerable bravery and daring as well.

Submarine mining can be effectually carried out either on the highest scientific principles or in the crudest fashion imaginable. Its earlier history clearly proves the enormous potentialities of mines constructed on the very simplest lines. In the American war of Secession, when so many vessels were sent to the bottom by torpedoes, the mines were more often than not of the most makeshift description. Wooden barrels made water-tight, filled with gunpowder, and fired by hauling lines or slow-burning fuses were the usual instruments whereby the Confederates conducted their subaqueous attacks on their opponents; for electricity and its application to submarine warfare was then only very

imperfectly understood. Yet nearly thirty vessels were sunk by these means, thereby clearly proving that mines have not necessarily to be of delicate construction to be efficient. On the other hand, it may perhaps be taken for granted that for every mine which accomplished the work for which it was intended, dozens of others failed ignominiously, as for instance in the case already referred to at the commencement of this work when Admiral Farragut brought his fleet safely over a mine-field which should, if it had been in an efficient condition, have utterly destroyed him. Yet even at the present time, as will be subsequently explained, our seamen are carefully taught how to prepare extempore mines from the crudest materials, and there is little doubt that, provided proper care and intelligence are displayed in their preparation, they will prove nearly as effective and reliable as the modern up-to-date submarine weapon. Of course mines constructed on such lines cannot be trusted to remain efficient anything like so long as those of more modern pattern, for apart from the innumerable accidents and dangers which must necessarily threaten anything fixed below the surface of the sea, there is the constant difficulty in maintaining perfect insulation and water-tightness. In modern mines these two most necessary attributes are kept constantly in view.

As in the case of torpedoes, the present construction of submarine mines has been arrived at after a long series of carefully conducted experiments, carried out with a view to discovering the best mode of firing and internal construction, and the different effects of subaqueous explosions. The first attempt ever made to carry out these experiments on a proper scale was that of the English Government in 1874, when the hull of the *Oberon* was altered so as to represent the *Hercules*, then considered one of the strongest ironclads afloat. Charges varying in

weight from 500 to 33 lbs. of wet guncotton were fired at various depths and distances from the hull, and the resultant pressures were indicated by crusher gauges fixed to the bottom of the ship. These gauges each consisted of a small steel cylinder and piston, containing a

P. Lange.

FIG. 25.—EXPLOSION OF 100 LB. GUNCOTTON.

pellet of copper which was compressed by the driving in of the piston when the shock of explosion took place. The size of the pellet, compared to what it was before the explosion, was then carefully measured by a micrometer. This pattern of crusher gauge, though in an improved

form, is still adopted in the Navy for measuring pressures in the powder chambers of guns. According to General Abbot's analysis the results of the experiments led to the conclusion that an instantaneous mean pressure of 5,500 lbs. per square inch exceeded the resisting power of the *Hercules*, and hence such a blow would cripple her in action. Colonel Bucknill, however, disputes the accuracy of these figures, and calculates that the pressure required "to produce a fatal effect on an ironclad is much nearer 12,000 lbs. on the square inch than 5,500 lbs." In the same year as the *Oberon* experiments other important ones were carried out at Carlskrona by a committee of Danish and Swedish officers, the target being practically the same as in the *Oberon*. Dynamite, rifle-powder, and gunpowder were used in the charges, which varied in weight from 660 lbs. of gunpowder to 13 lbs. of dynamite. The former charge, at a distance of nearly 24 feet, tore a hole in the outer bottom of 100 square feet, and destroyed the ship. These experiments were published in Commander Sleeman's book on torpedoes in 1880. From time to time experiments have been carried out by the naval authorities of the different Powers with a view to discovering the most effective range and the best relative position for the charge to the ship's hull. There can be no doubt that explosive compounds such as guncotton or dynamite give far more satisfactory results than mixtures such as gunpowder, the action of the former being more regularly distributed than in the latter, which is demonstrated by the readings of the crusher gauges (after gunpowder explosions) being most erratic, whereas in the case of guncotton or dynamite just the reverse happens. In fact there is everything to recommend the latter explosives for use in submarine mining. They take up far less space than gunpowder, and preserve their condition better; and

taken for equal explosive strength weigh only about one fifth.

The question of the best explosive compound for submarine mines has been exhaustively dealt with, in the course of experiments, by our Navy and Royal Engineers at home, and by the naval and military authorities of other countries as well. Every year, in fact every month, sees some new explosive brought out which the inventor claims to excel both in propulsive force and general handiness anything that has appeared before. Yet, although the number of explosive compounds is legion, very few are able to stand the test of submersion, and consequently the number suitable for submarine mining is comparatively limited. In a work of this size it would be out of the question to do more than refer to the chief and best known explosives used in mines, namely, dynamite and guncotton.

Dynamite is composed of nitro-glycerine mixed with a siliceous infusorial earth known as kieselguhr. The latter substance is first carefully calcined, and finally contains about 98 per cent of silica, with traces of lime and iron. Nitro-glycerine is a chemical combination of nitric and sulphuric acids with glycerine inflated into it by compressed air. Dynamite is of a reddish-brown colour, and is composed of 1 part of kieselguhr to 3 parts of nitro-glycerine. It burns with a yellow flame in small quantities without much danger, but if detonated it explodes with tremendous violence. One peculiarity about it, which renders it to a certain extent unsuitable for submarine mining, is that it freezes at 40° Fahr., in which state it is exploded with some difficulty, and when once frozen it sometimes remains so even after the atmospheric temperature has risen to over 50° Fahr. Charges of dynamite are made up in many different sizes and forms, and always wrapped in vegetable

parchment and packed in boxes covered with oil-paper; this prevents exudation of the nitro-glycerine, and guards against the evils attendant on handling it, its poisonous nature often causing the most violent head-aches to its users. The time of explosion of a dynamite charge when properly detonated has been calculated to occupy only the 24,000th part of a second.

Guncotton is a far safer and more agreeable explosive to handle than dynamite. It is chemically similar both as regards manufacture and detonation by fulminate of mercury, but with this exception, namely, that being a chemical combination of cotton waste and nitric acid, the difficulties in the way of getting rid of the free acid, are very largely increased, necessitating several distinct processes. With this end in view, the cotton finally appears as pulp, prior to its treatment in the hydraulic press, where the moulding into slabs and discs is effected. Wet guncotton is supplied in the service in 16¼-lb. tins; and dry guncotton in 2¼-lb. and 6-oz. tins, containing four 9-oz. discs and six 1-oz. discs respectively. Guncotton ignites at a temperature of 136° to 200° C., in striking contrast to gunpowder, which requires a temperature of 316° C. to ignite it. It emits no smoke, leaves no residue, and, most important of all, is not affected by moisture.

To ensure the presence of no free acid it is necessary that it should be examined regularly, whether in a dry or wet state. Dry guncotton is tested by pressing against it a small piece of blue litmus paper which has been moistened with a drop of water, when if the litmus paper turns red, the guncotton, being no longer in a proper condition, must be thoroughly wetted and condemned. Wet guncotton in mines is examined by careful weighing, to ascertain whether it has lost more than a certain amount of its proper weight by evaporation. In hot climates this test is carried out

out every six months in the case of the mines. Guncotton is stowed in wooden cases either in the guncotton magazine, shell room, or Whitehead magazine.

For the *fuses* or *detonators* of submarine mines, another explosive is used, far more violent in its effects than any ordinary explosive compound, namely, fulminate of mercury. This chemical salt is used not only to detonate the guncotton or

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FIG. 26.—EXPLOSION OF 25 LB. GUNCOTTON.

dynamite in mines, but also in torpedoes. In the Whitehead torpedo its manner of use has been already explained. In mines and spar torpedoes it is enclosed in a special pattern fuse which is used in both cases. This detonating fuse is constructed as follows:—A small wooden head has two holes bored into it and lined with metal. In these two holes are inserted the bared ends of two insulated wires,

which are kept fixed in their places by cement. The two ends of the wires are drawn through holes at the end of the cavities and bridged together by a very fine platinum wire. On top of the wooden plug a tin tube is fixed, filled with fulminate of mercury, while the space round the platinum wire is filled with guncotton dust. The detonator is fired by running an electric current through the wires sufficiently strong to fuse the platinum wire. The explosive force of these detonators is enormous, though only containing little more than a thimbleful of the detonating compound; and they require most careful handling, fulminate of mercury being most ticklish stuff to use. "Always handle detonators with the greatest care," says the torpedo drill book, and indeed every precaution imaginable is always taken with them when out of their tins. When going through the course of instruction in the *Actæon* the budding torpedo man is duly impressed with the respect which these little fuses are treated to. When practical instruction in detonators is going on a doctor always accompanies the class to be ready for emergencies. A particularly delicate business is the soldering up of the junctions. In doing this the operator holds the fuse and the soldering irons with his hands inside a metal case, so that in the event of an unexpected explosion the detonator will have to be satisfied with simply blowing off the operator's hands, instead of expending its energy amongst surrounding objects. Detonators are supplied in tin cylinders painted red and yellow, and each contains twenty-five. They are kept stowed in a special locker all to themselves, and, as may be expected, far away from the magazines.

Fulminate of mercury is the chemical combination of mercury with alcohol and nitric acid. After going through a thorough process of purification it appears in the form

of white silky crystals of a sweet taste. When in a moist condition the salt is perfectly safe; but when dry the slightest shock or friction will cause it to violently explode.

MINES.

There are two distinct kinds of mines in use in the British Navy—namely, the 500-lb. mine used as a counter-mine or as an observation mine, and the 72-lb. mine suitable for use either as an electro-contact or electro-mechanical mine. There are also certain means whereby mines can be hastily constructed out of makeshift material. We will now proceed to examine each kind in detail.

Observation Mines.

Observation mines are those which are placed under the direct control of an operator on shore. The naval procedure is to fire six or more of them simultaneously as the enemy passes over them. The operator on shore selects a suitable station where he can observe without being seen himself. The best way to accomplish this is to dig a pit in the side of a hill overlooking the mine field, large enough to allow the observer to be seated comfortably, and have easy access to his firing battery and key. If possible the observation station should be hidden with bushes, or whatever vegetation may be growing around; and if in barren ground, the roof should be painted as near as possible the same colour as the surrounding soil. Supposing the charge of each mine to be 500 lbs. of guncotton, its destructive area is a circle whose diameter is about sixty feet. Taking therefore the length of beam of an average

man of war as sixty feet, this means that six mines laid in a line would have a destructive i capable of defending a channel 720 feet wide.

The observation mine used in the British Navy 500 lbs. of guncotton. It consists of a cylindri made of Staffordshire plate, $\frac{3}{16}$-inch thick, 32·2 i

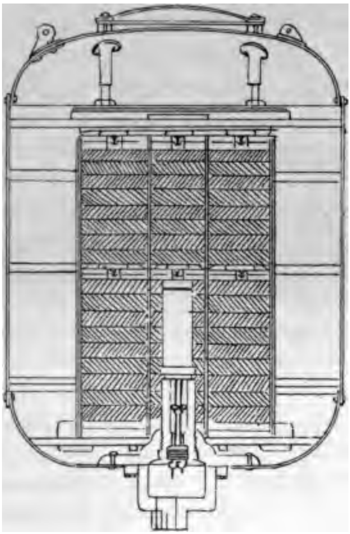


FIG. 27.—OBSERVATION MINE.

diameter, and thirty-four inches in depth with rounded off. Eye bolts are riveted on to the bottom of the mine for slinging it with, and for co the sinker chains to. Access to the inside of the given from both ends. The mine charge is pa twenty-two copper cases stowed in two tiers, e

being fitted with re-wetting holes; the centre copper case has a hole in it for the reception of a primer tin, which, as has been before explained, is used for the purpose of exploding the wet guncotton and consists of a tin filled with discs of dry guncotton with detonators fitted into them. The wires leading into the mine pass through what is called an "insulating plug" fitted in the mouthpiece of the mine. This plug is kept ready fitted for insertion into the mouthpiece of the mine, and has two 3-feet wires rove through it, the nut being placed at a distance of eight inches from one end of them. By means of "puddings" on the wires, gland nuts and leather washers, the insulating plug is kept absolutely watertight in the mouthpiece. The insulating plug being such an important part of the mine's construction, it is always carefully tested in every possible way before using.

The mine is fitted for service as follows. The dome, insulating plug, and mouthpiece are removed, and the outer legs of the insulating plug wires are insulated. A primer tin is then taken, and fitted with two detonators arranged "in series." After the detonators have been carefully tested the priming charge of dry guncotton is placed in the primer tin, the detonators are inserted, the mouthpiece screwed up tight, and the primer tin lowered into the mine. In doing all this the greatest care has to be taken that no undue force is used, and that the ends of the wires are carefully insulated and kept clear of any battery. After the primer tin is in place, the mouthpiece of the mine is screwed in, and the insulating plug properly secured into it. Lastly the dome is screwed on and the chains shackled on to the mine.

The mines are kept moored to the bottom by means of sinkers and mooring ropes. The buoyancy of a 500-lb. observation mine being 100 lbs., it is necessary to have moorings of some considerable strength, especially if the

mine is laid in a strong tideway or current. The weight of the sinker is about five cwt., and is made of wrought iron, and circular with a flat top. Its diameter is about two feet, the thickness varying according to the weight. The bottom of the sinker is slightly concave, so as to give greater hold and suction on the bottom, and the top has three lugs to which the mooring ropes and trippers for exercise are secured. The mooring ropes are made of flexible steel wire rope, of about 2-inch size, and with a breaking strain of about six tons. When mining for exercise a tripper chain is stopped along the cable, of sufficient length to reach from the sinker to the winch in the boat, to enable the sinker to be weighed without in any way damaging the cable.

Observation mines are generally laid out in a service 42-foot launch. In some ships a special launch is provided for the purpose, but an ordinary launch does nearly as well. Supposing a line of six mines is going to be laid, four stout thwarts, specially fitted at each end with slips, are fixed across the boat at equal distances, and securely lashed. These are meant for the mines to rest on. Light spars are secured above the thwarts, and a canvas wash strake is fitted round the gunwale to keep the boat dry. The boat being ready is brought alongside the ship, when the sinkers and mine slings are placed in position, and the mines are lowered into her. No. 1 mine is placed on the port end of the after thwart, No. 2 on its starboard end; No. 3 is placed on the starboard end of the next forward thwart, and No. 4 on its port end; and so on with the rest. Each mine is placed with its dome aft.

The cable which is to be used for the line of six mines comprises what is known as a half countermine circuit, and consists of a main cable 1,440 feet in length, into which are forked six branch cables sixty feet in length at intervals of

180 feet. The last branch is ninety feet from one end, leaving therefore 450 feet of "stray cable" at the other end. A large "Turk's head" knot is placed on the stray end ninety feet from the first branch. The cable commonly used has an insulated core of small section, armoured and coach whipped, and the branch circuits are of the same pattern as the main cable.

The cable is coiled into the boat as follows. The long end is coiled down forward until the tripper (already described) is reached, when it is coiled on the wash strake round the boat before No. 6 mine. When No. 6 branch

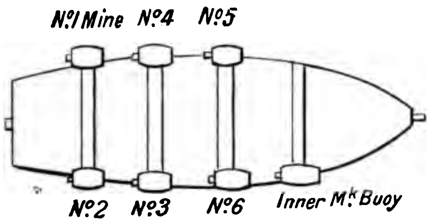


FIG. 28.—BOAT LOADED WITH OBSERVATION MINES.

is reached the fork is brought under the mine, lashed to the sinker, and the branch passed into the boat abaft the mine; the main cable is then stopped to the fore and aft spar, abaft No. 6 mine, and then taken underneath the boat and coiled up before No. 5 mine until the fork is reached when it is taken on to No. 4 as before, then underneath the boat again, and so on until No. 1 fork is reached, the cable being dipped under the boat between Nos. 4 and 3 mines, and Nos. 2 and 1, when the ninety-foot end of the cable is coiled down in the stern of the boat. As the cable is passed into the boat it is carefully tested by a "Menotti"

for continuity, etc. The cable being now in the boat, the dome of each mine is removed, the branch cables connected up to the legs of the insulated plugs, the domes replaced, and the mooring ropes attached to the mine chains. The ninety-foot end of the cable is insulated and secured to a barricoe. Before leaving the ship small buoys with buoy ropes are attached temporarily to the first and last mines for guiding the direction of the line whilst laying; a sinker with buoy and buoy rope is also taken to serve as a mark buoy. To ensure the mines being dropped at the proper intervals, a grass line is taken, marked with bunting at the points where the mines should be dropped in the line, so that when hauled taut the operators in the boat can see exactly when they have reached the proper distance for each mine.

When everything is ready for laying out, a mark buoy is taken away and dropped at a point sixty feet outside the position of the outer mine. The steamboat with the mining launch and a dingy in tow proceeds towards the mark buoy, and turning inwards, gets the leading marks on shore in line, and as she passes the mark buoy the barricoe with the ninety foot end of the cable is thrown overboard. The dingy then casts off, makes fast the grass line to the mark buoy, and the operators in the mining launch keep the line taut. The steamboat steams on, and as the first mark on the grass line goes over the gunwale the first mine is dropped, the cable runs out, and each mine is dropped as its respective mark on the grass line goes over the side. At sixty feet, after the last mine has gone, the sinker and inner mark buoy is dropped, the end of the cable is taken to the junction boat or station, and the grass line and small buoys are removed.

The line of observation mines is now laid, and the only outward evidence of its existence is the presence of the

two buoys marking its two ends. To deceive the enemy various buoys are laid all about and around the mine field, the operator on shore of course having the proper ones properly in sight and in line. When the enemy passes between the two mark buoys of any particular line of mines the firing key of the battery is pressed, and the line of mines fired.

In laying the mines particular care has to be taken that they are never less than twelve feet above the cable, as

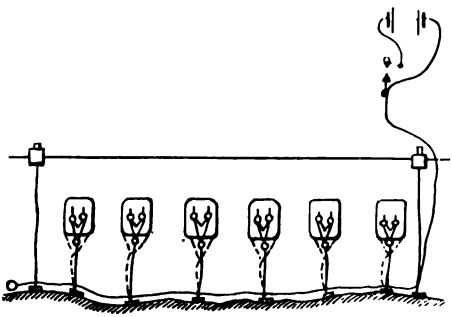


FIG. 29.—LINE OF OBSERVATION MINES.

it has been found by experiment that the explosion of the mines nearest the battery has in some cases cut the cable before the mines further along the line have fired. The best depth for a 500-lb. observation mine below the surface is about fifty feet.

Electro-Contact Mines.

An electro-contact mine, as its name implies, is intended for explosion when in actual contact with a ship's bottom

or side; consequently there is no need for it to contain such a heavy charge as the observation mine, whose function is to destroy a ship at a certain distance. The explosive charge of an electro-contact mine is about seventy-five lbs. of wet guncotton, sufficient to utterly disable if not sink any ship afloat. It is so absolutely under the control of the operator that it can be immediately put out of action by the very simple process of disconnecting the key of the firing

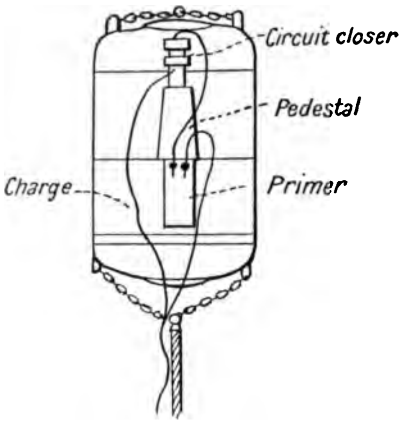


FIG. 30.—ELECTRO-CONTACT MINE.

battery. On the other hand its peculiar construction prevents it being fired unless in actual contact with a ship's bottom, or unless subjected to a very severe blow. Its construction may be roughly described as follows.

It consists of a cylindrical iron case with its ends rounded off and the outside fitted with eye bolts for connecting the sinkers to. The charge is stowed in copper cases, the centre one having a hole in it, for the reception of the primer tin.

The bottom of the mine is fitted with an insulating plug the wires being rove through the insulating plug and eight feet long, one of them being marked to distinguish it from the other. In the centre of the mine and over the charge is a platform on which is fixed a pedastal, and on top of this pedestal stands what is termed the "circuit closer." The purpose of this instrument is to complete the electric circuit when the mine is struck by a passing ship. Many different patterns of circuit closers have been invented and adopted by ourselves and other countries, and most of them are perfect little marvels of ingenuity and delicate mechanism. In the Navy, however, simplicity of construction is always aimed at; and though the form of circuit closer used in that service is far from being the best, it, at any rate, is quite good enough for mines which have not to remain submerged for any great length of time. The circuit closer consists of a vertical steel cylinder, and, passing through the mouthpiece and insulated from the body of the cylinder, is an iron spindle which points down into the tube. The lower part of the cylinder is filled with the purest re-distilled mercury up to a point just below the other end of the spindle, to such a height that when the circuit closer is tilted over to an angle of 70°, but not less, the mercury should come into contact with the spindle, and by doing so should complete the circuit running through the wires connected with it. The greatest care has to be taken that the mercury is kept perfectly clean and dry, otherwise a scum of oxide forms on its surface and prevents the contact being perfect. The circuit closers are always kept charged with mercury, ready for instant use, and if loaded in a dry place and with proper precautions there is no reason why they should not remain efficient for a considerable time. Before being placed in the mines they are carefully tested.

To prepare an electro-contact mine for service, the circuit closer is tested, and the inner and outer legs of the wires passing through the insulating plug are examined, tested, and insulated. The inner leg known as the "return" wire is joined to the terminal at the base of the circuit closer, which is fixed in its place by four screw nuts to the pedestal after the primer tin is in place. The primer tin with the two detonators, having been first tested, is then inserted into the mine, the inner leg or marked wire is joined up to one leg of the detonators, and another short wire is connected to the upper terminal of the circuit closer and the other leg of the detonator. As will be seen on reference to the diagram, a complete circuit is now formed when the mine is tilted enough to make the mercury effect a contact in the circuit closer. The mine is now ready fitted.

Electro-contact mines are laid in the position shown in the diagram on the next page.

The mines are laid in groups of three, each group with its three connecting cables being brought to a disconnector box, the latter being in turn connected by connecting cables to a multiple junction box at the end of the multiple cable. The purpose of the disconnector box is to cut a mine out of the circuit after it has been fired by contact, so that when the circuit is completed in another mine it will not be short-circuited by the broken ends of the exploded mine; the disconnector for each mine is therefore in series with that mine, the bridges fusing simultaneously. The box is closed and made water-tight by means of a mouthpiece similar to that used to close up a primer tin.

The junction box is simply an iron box containing the junction of the main with the branch cables. The ends of the cables are "puddinged," drawn together and connected inside the junction box. The puddings of the branch cables are nipped by hooks which have their lower

ends threaded, and screwed down by a nut outside the box.

The cable used in the Navy for electro-contact mines is similar to that used for all other mining, and is 1,000 yards long. It is cut into eight lengths, namely, six lengths of 100 yards and two lengths of 200 yards, and puddings are

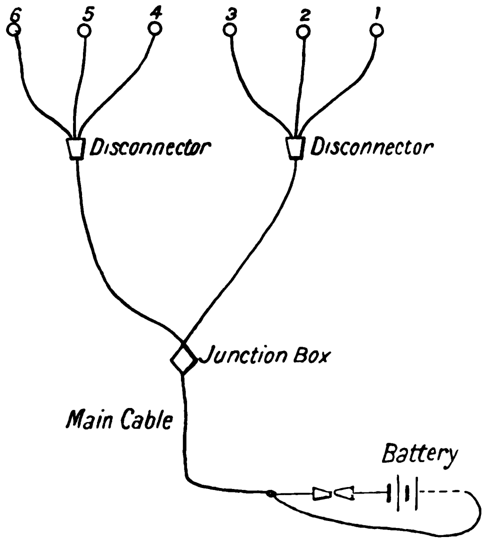


FIG. 31.—PLAN OF LAYING ELECTRO-CONTACT MINES.

formed at each end. As will be seen from the diagram each mine is connected to its disconnector box by a 100-yard length, and each disconnector box is connected to the multiple junction box by a 200-yard length. The main cable between the junction box and the battery is a seven-core one of the same pattern as that which is used with observation mines.

Supposing that two groups of electro-contact mines are to be laid. In the first place the mines with their branches are passed into a launch and placed as follows. No. 1 is placed aft on the port side, No. 2 next to it, No. 3 aft on the starboard side, No. 4 next to it, No. 5 next to No. 4, and No. 6 on the port side next to No. 2. The disconnector box of each group, together with the 200-yard length, is placed in a separate gig, and mark buoys are placed beforehand to show the place where each mine is to be dropped. The boats having proceeded to the mine field, the mine boat proceeds to drop the mines opposite their respective buoys. On arriving at No. 2 buoy of each group the gig containing the junction box and 200-yard length is slipped, and keeps them clear and taut by pulling towards the direction of the junction boat. The disconnector boxes with the branch cables are let go, when the 100-yard lengths are fairly taut, and the 200-yard lengths taken to the junction boat, where they are joined to the cores of the multiple cable. The shore or observation end of the cable has a firing battery of twenty boat's cells connected up to it, the core and armouring of the cable being taken to the opposite terminals. When it is wished to place the mines in action, the battery is plugged into the circuit and closed, and all that is then required is the bumping of one of the mines by a passing ship, and the consequent completion of the circuit by the tilting of the mercurial circuit closer. The act of doing this fires the detonators and the mine.

A most important element in the successful laying of electro-contact mines is the accuracy of the soundings, so that due allowance shall be paid to the rise and fall of the tide, and effort made to retain the mines at their most effective depth, namely, ten to fifteen feet. In harbours where the rise and fall is only a few feet careful soundings can ensure

the laying being carried out efficiently; but in places where there is a difference of, say, twenty feet between high and low water, the work of laying a main field of electro-contact mines is exceedingly difficult, for if fitted with fixed mooring lines some at least of the mines will be floating on the surface at low water and too much submerged at high water. Various contrivances have been invented for keeping mines at a constant depth, but all of them are somewhat liable to get out of order, and in the Navy, at least, contact mines are generally laid with fixed mooring lines. At the same time it must be remembered that, owing to the advances now being made in the science of submarine warfare, the plan of mine-laying is becoming every day more perfect.

Electro-Mechanical Mines.

Electro-mechanical mines are the most dangerous type of all, at least to their users. Each mine after being laid is left entirely to its own devices, being under no control whatever from the operator in the ship or on shore. Electro-mechanical mines are not used for the defence of harbours, but for blocking the entrance to an enemy's port, and the one great advantage about them is that they can be laid expeditiously either from a ship or a boat in any position or order.

In construction the mine is identical with that used in E. C. mining, the same mine being used for either purpose; the battery in this case, however, being inside the mine, and consisting of two boats' cells. A short wire leads from the upper terminal of the circuit closer to the terminal of one of the boat's cells; another short wire leads from the lower terminal of the circuit closer to one of the detonators in the primer. The two inner legs of the wires leading through

the insulating plug are connected to the terminal of the other boat's cell and the other detonator respectively. In the base of the mine, outside the insulating plug and protected by the protecting plate, is placed what is called a circuit breaker, into which the two outer short legs of the insulating plug wires are fitted. This circuit breaker consists of a brass cylinder in which work the ebonite discs with two insulated wires fitted at their inner ends with copper discs. Between these discs is poured a certain quantity of melted sugar, which is allowed to harden and thereby insulate the two discs from one another. When the mine is lowered into the water this cake of sugar is gradually dissolved, and the ends of the two wires come together, thus completing the circuit; or rather the circuit is complete when the mine is tilted and the mercury in the contact closer touches both its terminals.

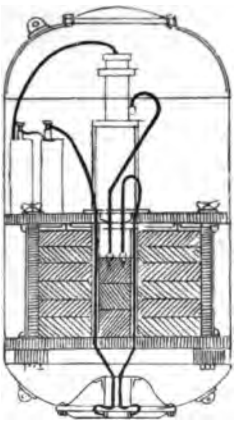


FIG. 32.—ELECTRO-MECHANICAL MINE.

As may be imagined, the greatest care has to be taken in lowering the mines into the water to see that they are kept perfectly upright, and the sugar in the circuit breaker kept dry until the last moment. The same difficulties in regard to the rise and fall of the tide apply with equal force to electro-mechanical mines as they do to electro-contact ones. Instances have been known where mechanical mines have broken adrift and constituted a most formidable danger to friendly vessels. Taking them altogether, these mines constitute the least desirable form of mining that exists; but, as has been

already pointed out, occasions may arise when their adaptability for laying quickly, outbalances their otherwise great disadvantages.

Extemporised Mines.

Extemporised mines are generally made out of casks or barricoes. When in this form, however, they cannot be laid at a much greater depth than twelve fathoms, and then only when the cask has been strengthened internally. At greater depths the pressure is so enormous that the water is actually forced through the pores of the wood. So twelve fathoms must be taken as the practical limit. Wood in fact is a very bad material for mine cases, and especially bad in extempore mines, where gunpowder is used as the charge, for when the explosion takes place the wooden envelope is so weak that large masses of powder are blown into the water before they have time to ignite. Still it must be remembered that wooden mine cases are after all only extempore or makeshift appliances, and they at any rate are always handy on board ship, and can be quickly made in any shape or size. The best way of strengthening a cask is by inserting a stanchion fitted with a cross piece at each end, and making it bear against the ends of the cask. Different-sized casks can be used for mining, from the seventy-two gallon to the twenty-five gallon size, but it must be remembered that the larger the cask the more liable is it to leak when submerged, owing to its comparatively loose construction and the difficulty in strengthening it. A seventy-two gallon cask will carry about 650 lbs. of gunpowder and stand a depth of six fathoms, while a twenty-five gallon cask will take 225 lbs. of gunpowder and stand a depth of twelve fathoms. The casks after

being strengthened internally in the manner described are painted with a thick coat of tar, inside and out.

One method of preparing an extemporised electro-contact mine is to take a twenty-five gallon and a fifty-four gallon cask, and fit them so that the smaller cask is contained in the latter. The guncotton charge with its primer and detonators is placed inside the smaller one, together with the circuit closer. The wires from the smaller cask pass through the larger one, and the intervening space between the two casks is filled lightly up with layers of shavings, particular care being taken that the chine of the inner cask does not rest on the slack wire. The mine having been thoroughly tested for insulation and continuity, a weight of about seventy lbs. is attached to the slings for the purpose of keeping the mine upright in the event of the tide falling low and the mine floating on the surface. Extemporised electro-mechanical mines are fitted up in the same manner, a platform being made for the batteries to rest on, and the contact breaker being placed inside the bottom of the larger cask. The mines are laid out and moored in the same manner as in the case of ordinary service ones. They are very liable to get out of order after being submerged for about a week, leakage chiefly taking place by the holes at the head of the casks which the conducting wires lead through. The holes are made as water-tight as possible by surrounding the wires at the point of entrance with plates and rubber washers screwed hard down.

A light mechanical mine can also be hastily constructed with two ten-gallon barricoes lashed to a twelve foot plank. One barricoe contains the firing battery of two boats' cells; the other the circuit closer, which is adjusted to a tilting angle of about fifty degrees. The charge of about twenty pounds of guncotton with a primer is slung five

feet below the plank, and the mine is moored with a pig of ballast made fast to a mooring rope at each end of the plank, enough slack being allowed for the rise and fall of the tide. In substitution for the circuit breaker a "safety length" of wire is fitted to the mine. Its ends are insulated until the mine has been laid, when it is connected up, moored with a shot and small buoy, and carefully lowered into the water.

Extemporised mines are often used for supplementing a mine field of ordinary service mines.

CHAPTER VIII

MINE DESTROYING

MINE destroying more closely concerns the Navy than mine laying; consequently in the Navy the system of mine laying is at best necessarily of a more or less makeshift description, whereas mine destroying is carried out on the most carefully considered and scientific principles. There are three different modes of destroying a mine field—namely, by "countermining," "sweeping," or "creeping." The object of these operations is to sweep a clear and safe channel right through a mine field for the attacking ships to pass through. But sweeping, being only possible when not under fire, would not be undertaken except in outlying positions where groups of mines with buried batteries were considered by the attackers as likely to be met with. On the other hand in countermining, which would be invariably carried out under fire, quickness is the first desideratum, and it is especially desirable that the whole of the work should be as automatic as possible, so that nervousness on the part of the operators or sudden casualties may not interfere with its successful accomplishment.

Countermining.

The process and object of "countermining" consists of the destruction of a mine field by laying a fresh line of mines across it and exploding them.

An ordinary line of countermines consists of twelve 500-lb. mines of the same pattern as observation mines. The cable is cut in the same way as the cable in the observation mine circuit—namely, 1,440 feet long with six branches 60 feet long forked into it at intervals of 180 feet, the two ends being 90 feet and 450 feet long respectively, and as two of these circuits are used for the twelve mines, a line will clear a channel 720 yards long. The firing batteries consist of two lots of eighty boats' cells, one lot at each end of the cable.

In many ships nowadays the mines are laid out in a specially-built countermining launch. In all other ships the ordinary service 42-feet open launch is used, and ballasted with about four tons of pig iron. Seven solid timber thwarts of the same pattern as those used in laying observation mines, and fitted with slips at each end, are placed across the gunwales of the boat and securely lashed. Light spars are secured round the boat above the thwarts as for observation mines, to which are laced the canvas wash strakes round the boat. All the oars and ordinary fittings are taken out.

The launch having been prepared, is hauled alongside the ship for loading. The sinkers, with their mooring ropes and slings attached, are first hoisted out, and their rings, together with those of the mine slings, are placed over the slips at the end of the thwarts; the sinkers thus hang overboard just clear of the water. Each mooring rope is coiled down near its own sinker, and if only for exercise its "tripper" is also bent to it. The trippers and mooring gear now being in place, the mines are hoisted out and placed, the first six as for observation mines, those from six upwards alternately, with their domes aft. The mines, together with the buoys, are placed in the order shown in the sketch over-leaf.

The three buoys are meant to mark the channel cleared, and are dropped in the following order, viz., No. 1 at the commencement, No. 2 in the middle, and No. 3 at the end of the line of countermines. At night Holmes lights (see page 29) are fitted to them, so that the channel can be clearly seen; for the buoys are so strongly constructed, and are so far from the explosion, that they remain floating in position after the line of countermines has been fired. By this means the newly-cleared channel is clearly defined. As each mine is lowered into the boat, its slings, which have already been lowered into the boat and placed over the slip,

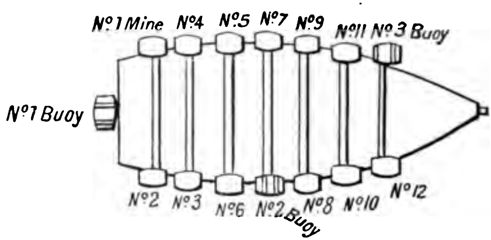


FIG. 33.—METHOD OF LOADING COUNTERMINING BOAT.

are attached to it, while the dome is removed and placed on the thwart near it.

The mines and gear now being in position, the cable is passed into the boat. Supposing two half circuits are being used, the long end of one of them is joined up to a single test-battery on board the ship and the bight paid overboard into the boat. When the Turk's-head knot, which it will be remembered is placed 360 feet from the end, is reached, it is secured to No. 3 buoy to which also two fathoms of the cable are stopped, the bight being brought down on the after side of the buoy, and the slip lanyard bent on. The

Symonds & Co.

FIG. 34.—EXPLOSION OF A LINE OF COUNTERMINES.

cable is then continued to be coiled up outside the buoy and lightly stopped up with single rope yarns. When the first branch wire comes into the boat, the cable is slipped under the boat, the junction box laid on top of No. 12 mine, and the branch hauled into the boat, its ends being kept insulated. Another two-fathom coil of the main cable is then stopped up, and the slip lanyard bent on as before, and the cable and next branch are taken to No. 11 mine. So on through all the length of the cable, which as far as No. 2 buoy passes under the boat at each mine, and after then only at each alternate mine. When the short end of the first half-circuit is arrived at it is joined to the short end of the second by a junction box, which is lashed on top of No. 2 buoy. The Turk's-head knot on the long length is lashed to No. 1 buoy, and the 360-feet length is coiled up and stopped to the buoy. The cable being now passed into the boat, the branches are connected up to the mines and the latter closed. One of the firing batteries is placed on board the steamer towing the countermining launch, and the other battery on board the ship, or a towed battery boat. Lastly, a small red flag is secured to the end of each cable, so that the officer in charge of the boat can always keep them in sight and at hand, the ends of the cable being triced up both in the steamer and battery boat.

All being prepared on board the countermining boat, her crew have only to await the order to proceed about their work. The favourable moment having arrived the tug or gunboat takes the countermining launch in tow. One end of the cable is kept on board the ship which has closed up nearest the scene of action, or else on board the battery boat which is towed with the launch until signalled to anchor.

Everything now depends upon the celerity and coolness

of the operators. The steamboat proceeds at the fullest speed, being steered on a pre-arranged bearing. At the point where the mine-field is to be attacked begins, the first buoy is thrown overboard, and the boats rush on. As the cable flies out the yarnstops are carried away in succession until the slip of the first mine is reached, when the tension on the cable releases it, the mine and its sinker go to the bottom, and the cable goes on paying out until the next mine is reached, when the process is repeated, and so on until the whole line of mines is dropped. When the third buoy has gone overboard, the towing steamer at once hoists a red flag, or, if at night, fires a rocket. This is the signal for the firing batteries at the two ends of the cable to be joined up. A second signal indicates the pressing of the firing key by the officer in the steamer and the firing of the line of the countermines, when the circuit is completed by the simultaneous pressing of the key in the firing-battery at the other end of the cable.

If the channel to be cleared is a very long one, lines of countermines can be laid in line with one another with their ends overlapping, or if a channel of 360 feet is required the two lines can be laid parallel to one another, in which case the lines must be fired simultaneously by signal. In action the automatic principle of countermining shows its chief usefulness in the fact that no one need be on board the launch itself whilst running the mines, the first buoy being dropped overboard by a hauling line from the towing steamer, and the mines being dropped automatically in the manner already described.

Sweeping.

"Sweeping" is the most tedious and unreliable mode of destroying a mine field, but if carried out without hurry

and unexposed to gun-fire it is useful for clearing a moderately wide channel. Before sending away boats to sweep for mines, the suspected mine field should be carefully scanned at low water for signs of mines floating on the surface, and if any such appear they should be destroyed by fire from the quick-firing and machine guns of the attacking ships. When the tide has risen a few feet the boats should be sent away to sweep, careful note

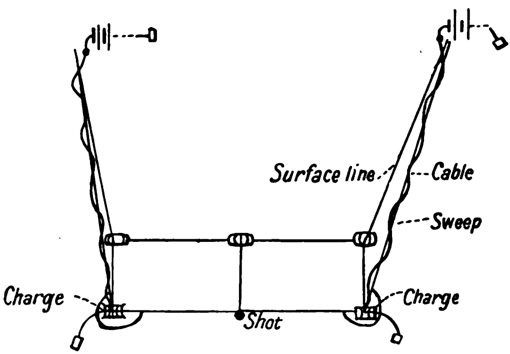


FIG. 35.—PLAN OF SWEEP.

having been taken of the positions of any part of the mine field which came in sight at low water.

Two boats are employed in the manipulation of a sweep. The latter is composed of 20 fathoms of two-inch rounding with charges of gun-cotton at each end, fitted with irons to catch the mooring ropes of mines. It is suspended by lines from three floats attached to the centre and ends, the upper ends of which are connected by a surface line of the same length as the sweep. Each end of the sweep and surface line is tailed with 55 fathoms of two-inch rounding and one-inch rope respectively. The conducting wire is

stopped along the tails of the sweep, care being taken that it is so secured that no strain can come on to it when the sweep is being used or when an obstruction is met with. A wire rope 4 fathoms long is spliced into the ends of each sweep and tail, 8 feet on each side of the charge, so that when the latter is fired the sweep will not be completely severed, and can therefore be hauled into the boat to be fitted with a new charge.

The two boats selected for the work of sweeping should draw as little water as possible, so as to reduce the possibility of their collision with the mines to a minimum. The sweep, with the conducting wires, charges, and surface line is placed in one boat. Each boat is supplied with a large anchor and cable and a boat's battery of ten cells. On arrival at the passage selected, one end of the sweep and conducting wire is given to the other boat, which pulls away in a line at right angles to the channel. When the third buoy is overboard, the boats turn in the direction of the channel and pull slowly up it, the operators in each boat carefully tending the sweep and wires, and "feeling" for any obstructions. Great care must be taken that the leading marks for the channel are kept in line and that the line of three buoys with the surface line is kept as straight as possible. When a sudden strain on the sweep is felt, the boats pull and gradually close. By carefully noting the position of the buoys and surface line the position of the obstruction can be discovered. Directly this is done the boats pull and bear the sweep so as to bring the nearest charge up against the obstruction. The sweep and wires are then paid out until the boats are at a safe distance, the firing battery is connected up, and the charge fired. The sweep is then pulled up, the short length of wire at the charge having kept it intact. A new charge is then fitted and lowered, and the boats continue the

sweep, particular care being taken that no part of the channel is passed over unswept while the sweep is being refitted.

Occasions may occur when the boats detailed for sweeping have to pass over suspected mine fields on their way to the place selected. In that case they proceed in single column in line ahead, so that the foremost boat only will be destroyed in the event of collision with a mine. Several pairs of boats can sweep together if a wide channel is desired. In this case the outer boat of each pair keeps right astern and well clear of the centre float of the next pair ahead. When sweeping a channel particular care must be taken that the cleared space is distinctly marked out by buoys or other means, and, if time will allow, every channel should be swept twice before it can be relied upon as being safe and clear.

Creeping.

"Creeping" is perhaps the most efficacious mode of destroying cables, chiefly because it can be carried out with little precaution and with the least display on the part of the operators. The object in creeping is not to catch the mines themselves but the electric cables, and therefore the operation is generally carried out near the shore or where the cables are likely to be found lying in comparatively shallow water.

Two creeps are used in conjunction; an explosive grapnel and an Admiralty pattern creep as well. The explosive grapnel consists of a charge of about 2¼ lbs. of gun-cotton contained in a primer tin and fitted with detonators. This charge is surrounded by three large steel hooks turned outwards, and fixed to the grapnel and charge is a stout rope with a single insulated cable carefully

stopped along it. One end of the cable is taken to the battery in the boat, the other end to one of the detonators in the charge. The other detonator is connected to a wire and earth-plate. The Admiralty creep is simply towed for hooking the electric cables with, and contains no charge at all.

The boat chosen for the work is preferably a steamboat, but a light gig even is quite good enough. Everything being in readiness it proceeds cautiously to the scene of action, when if not under much fire the Admiralty creep is thrown over the stern and the rope paid out. The explosive grapnel is thrown overboard from the other quarter and its tow rope and cable paid out also, the Admiralty or non-explosive creep being towed five fathoms astern of it. When the operator on the boat feels a tug on the grapnel rope he hauls it well taut, connects up the cable to the battery, and fires the charge. The cable which has been caught will probably not be completely severed, so while the exploded grapnel is hauled in, the boat proceeds until the following Admiralty creep catches the cable. The crew then man the rope and haul in until the caught cable is in sight. If time and circumstances will allow it, it is often best to underrun it so as to arrive perchance at a multiple junction-box, when a whole row of mines can be connected up to the boat and fired; or more generally the cables are cut. If under heavy fire only the explosive grapnel is used.

Although creeping cannot be carried out with any degree of success on a rocky bottom, there is no doubt that in war time it will be the favourite mode of destroying mines. When whole mine fields have to be cleared away *en masse*, countermining of course will be carried out, but for obvious reasons this operation would be extremely hazardous, if not hopeless, under the fire of batteries on

shore. When the circumstances are so urgent that a passage must be forced through a mine field at once and at all hazards, as, for instance, on the sudden and unexpected arrival of a fleet before the entrance of a well-defended harbour, the best course would be to follow in, in single column in line ahead, six cables apart, and the least valuable ships leading. The small ships could tow chain cables along the bottom in pairs, as a sweep. Whether a mine field be destroyed however by the means suggested by the three other methods described in detail, the whole success of the operation will depend not so much on the efficiency of the materials applied, as on the coolness and intelligence of the operators themselves. In the British Navy this great desideratum is fortunately not wanting.

Fig. 36.—H.M. Torpedo School Ship "Defiance."

TORPEDO VESSELS

CHAPTER IX

TORPEDO SCHOOL SHIPS

THERE are at the present time two torpedo schools in the navy, namely the *Vernon* at Portsmouth and the *Defiance* at Devonport. It is the intention of the authorities to establish another school at Sheerness, but in any case the *Vernon* and *Defiance* may be taken as models of any other school which may be started for the purpose of relieving them of some of their work.

Both schools are located in old wooden hulks specially fitted for the torpedo training service. Large class rooms with all the necessary apparatus for teaching the theory and practice of torpedoes, mines, and electricity are fitted up on board, and a large flotilla of torpedo boats, picket boats, mining launches, &c., are supplied for the more practical part of the instructions. A large store of torpedoes, mines, and electrical apparatus of every pattern and size are supplied; in fact, everything that touches in the slightest way the special work for which the pupils are qualifying. The training staff of each ship consists of a number of torpedo lieutenants and torpedo gunners, assisted by a class of petty officers known as "torpedo instructors" and "torpedo artificers."

The torpedo service trains and supplies to the fleet the following ranks and ratings—

Torpedo Lieutenants (Lieut. T.); Torpedo Warrant Officers (Gunner T., Boatswain T.); Torpedo Instructors (T.I.); Leading Torpedo Men (L.T.O.); Seaman Gunner Torpédo Men (S.G.T.); Torpedo Artificers (T.A.); Torpedo Coxswains (T.C.). We will take these in order, and describe generally their special training and duties on board ship in peace or war.

Torpedo Lieutenants.

Every year, in May or June, five or six lieutenants are chosen from the lieutenants of the fleet to qualify for torpedo lieutenants. They are chosen from volunteers; any lieutenants who wish to become Lieuts. T. forwarding an application to the Admiralty to pass for that rank, and the candidates being selected from the list of these volunteers. The principal qualifications for the post are good certificates in the examinations they have gone through when passing for sub-lieutenants, good reports from the captains they have served under, and not too great seniority, although they must have kept watch as lieutenants at sea for at least a year.

The candidates selected join Greenwich College in October, and study higher mathematics, chemistry, and physics for seven months, passing a severe examination in the following May. They then join the *Vernon* at Portsmouth to go through the practical part of their course, and study practical electricity, and all matters connected with mines, torpedoes, and electrical communications, which latter include everything connected with electricity on board ship. That these are many may be seen from the following list of electrical fittings found on board ship :

Firing batteries and circuits for firing guns.
Firing batteries and circuits for ejecting torpedoes.
(T) Electric engine-room telegraphs.
(T) Electric steering telegraphs.
(T) Electric helm indicators.
(T) Electric revolution indicators.
(T) Electric flashing signal lamps.
Electric bells and indicators.
Internal incandescent lighting.
Search lights.
Dynamos and motors.

As there are many different varieties of most of the above in the service, notably those marked (T) which are in a transition state, the Admiralty not considering them to have been sufficiently tried, or sufficiently trustworthy to be accepted by the service for general use, it will be seen that nine months, which is the length of this course, is none too much for acquiring a thorough knowledge of them.

When a lieutenant has passed his examinations at Greenwich, and in the *Vernon*, he becomes a Lieut. (T.), and when appointed as such to a ship he gets extra pay according to the results of those examinations—1st class, 3*s*. 6*d*. a day; 2nd class, 2*s*. 6*d*.; 3rd class, 1*s*. 6*d*. His duty on board ship in peace time is (1) to keep all the articles enumerated above in good order and efficient; (2) to carry out the various torpedo exercises ordered by the Admiralty; (3) to see that every opportunity is given to the untrained men in the ship to be instructed in torpedo and electrical subjects; (4) to act as professional adviser to the captain in torpedo work. In addition to these matters a torpedo lieutenant is supposed to be well versed in the method of defence adopted by foreign nations for their harbours, and consequently in the best means of attacking them; also in the system adopted by the Royal Engineers for the defence of our own harbours, so that he may, if called upon, assist them

in the defence of our colonial harbours; and have a knowledge of the mines over which our ships must pass when entering our own ports.

Before an action between fleets, or vessels, he would lay his ideas of how the torpedoes should be worked before the captain, and receive orders from him; should the captain (or admiral) give orders to fire the torpedoes under certain conditions, he sees that the torpedoes are ready, and himself fires them at the appointed time, unless the torpedoes are fired from more than one position, in which case he would be assisted by another officer.

Although in no way connected with his military duties, a torpedo lieutenant should have a good idea of decorating ball rooms, town halls, &c., with electric lights, for it is not only useful for the ordinary entertainments given by our ships when serving in colonial waters, but it also has a national importance when entertainments of any kind are given to foreign fleets or ships, as witness the *fêtes* given at Portsmouth to the Italians, the decorations and illuminations for which were almost entirely worked by the *Vernon.*

When it is known that in a seagoing ship a Lieut. T. has very frequently to carry out the ordinary duties of a lieutenant, keeping watch in regular turns with the others; remembering too the fact that all exercises, drills, and the state of all electrical fittings have to be daily entered in the various books and reports required by the Admiralty, it will be seen that his time is more than filled up, and that he will eagerly welcome the day to come when there will be enough lieutenants on board a ship to set him free to carry out his proper duties thoroughly and with credit to himself and to his country.

Torpedo Warrant Officers.

A warrant officer is selected to qualify in the *Vernon* r this rank according to his certificates and reports from ptains under whom he has sailed. In this case, as in l others, the candidates are volunteers. Classes of arrant officers are commenced every month in the torpedo hools; consequently there is a constant flow of them into le service. Their course lasts about twelve months, consting of a small theoretical course of mathematics and ectricity, and a severe practical course in the care and anagement and repair of all articles, connected with rpedoes, mines, and electricity, carried in a man-of-war. his course is longer than that for a Lieut. T. on account the smaller amount of education that a warrant officer is on commencing, as compared to a lieutenant; but he arns a somewhat reduced amount, the lieutenant having far sounder knowledge of electricity, explosives, and eir manufacture. Torpedo warrant officers are usually nt to ships too small to carry Lieuts. T. and yet large ough to require an officer to look after their torpedo and ectrical fittings. Such are 2nd class cruisers, 2nd class ttleships, &c. They are also sent to flagships in addition a Lieut. T. to assist him in his general superintendence the fleet. On account of their knowledge gained of ores, during their previous service as warrant officers, ey are sent to look after the stores and fittings in the ckyards and in ships in the Reserve, to see that they e not allowed to deteriorate.

Torpedo Instructors, Leading Torpedo Men, Seaman Gunner Torpedo Men.

These ratings are designated by the letters T.I., L.T.O., and S.G.T. placed after a man's names; there is also another rating which must be brought in to fully explain these rates—viz. trained man, or T.M. as he is called. It will be best to start with the latter, and to work gradually up to the higher ratings in this explanation, as all the above ratings are held by bluejackets, and each rate has to be passed through to reach the higher ones. Every bluejacket on ceasing to be a boy becomes an ordinary seaman; up to this time he has been through the boy's training, but has had no special education. On becoming an ordinary seaman he has to pass for T.M., a rating which carries with it an extra 1*d.* a day, and for which he has to requalify every three years. To become a T.M. he has (amongst other things) to go through a slight torpedo course, which teaches him little more than the names of the various articles, and gives him confidence by seeing mines, explosives, torpedoes, &c., handled, thus preparing him for the day when he shall handle them himself.

We will take the case of a man who is going to get on in the service. After a few months as an ordinary seaman, he passes for A.B. (able seaman) and is rated. He then applies to pass for a S.G. (seaman gunner), and being of good character, is sent to a gunnery school as soon as an opportunity occurs to qualify, or if there be no opportunity, he qualifies for an acting S.G. on board his ship, and is then competent to receive the acting rate when a vacancy occurs, going to the gunnery school to be confirmed when the ship pays off.

When he has passed for a S.G., if he has got a first class

in his examination, he is allowed to volunteer to qualify for a S.G.T. on board one of the torpedo schools, and if there is a vacancy he is accepted. He then goes through a three-months' course in torpedo work, learning a certain amount of electricity, how to adjust torpedoes, to fit mines, and to handle explosives; the course being very practical and as little theoretical as possible. An examination comes at the end of this course, and directly he passes he gets *3d.* a day extra if first class, *2d.* if second, and *1d.* a day if third.

Having passed as a first class S.G.T., the man looks round to see whether his bent is towards guns or torpedoes; if the latter, he volunteers to qualify for a L.T.O. Supposing that the man has been a long time in harbour he will be sent to sea for about twelve months, to keep him in touch with the numerous things that are met with only at sea, but which no seaman can afford to forget, and then goes to the torpedo school to learn more deeply the intricacies of the electrical and torpedo subjects which he skimmed over in his S.G.T. course. The L.T.O. course is of necessity somewhat theoretical, in order that those qualifying for that rating may have a more thorough knowledge of matters electrical, for in many gun vessels and torpedo craft L.T.O.'s are in charge of all the torpedo and electrical fittings.

When he has qualified, the L.T.O. goes to sea for a period, generally in a big ship so as to learn more thoroughly the practical side of his duties, and, in connection with this, it may be observed that in all special ratings in the Navy, whether with officers or men, they learn the theoretical part of their duties in the various schools, and also gain a theoretically practical knowledge; but the real practice is only to be learnt in a seagoing ship. For there is a great difference between knocking off

work in the evening knowing that you are going to run a certain kind of torpedo the next day at 9 A.M., and going to bed in a sea-going ship not knowing whether you may be roused out at midnight to work a search light, or be told at 5 A.M. to run a line of mines, or to fire a torpedo. It is this training which teaches officers and men to be always ready for anything, and of course the best men are those who are readiest.

Our L.T.O. now turns his attention to becoming a T.I. He works hard, for he knows that on his reports depend his chances of being allowed to qualify, and knowing as he does the subjects which he will have to learn if selected, he works them up in his spare time. When selected he goes back to the torpedo school for about nine months' training, which is of the same nature as before, but of a far more intricate character; and it may with truth be said that if he succeeds in passing this final examination, he has become a fair scholar, and a good and trustworthy electrician with a very fair knowledge of mechanics. This statement indeed is borne out by facts, for very many naval pensioners who have been T.I.'s are at this day employed at good wages by our large electrical and other firms, for which their habits of discipline and steadiness specially fit them.

Should a T.I. elect to pass for a warrant officer, he does so in the usual way, and then generally goes in for a Torpedo warrant officer.

Torpedo Artificers.

These are men who have been brought up as blacksmiths in the navy, and who feeling themselves capable of being something better have passed for armourers. Then

turning their attention to torpedo work they volunteer to pass for T.A. This is a long course, and requires men who have the strength and ability of a blacksmith combined with the skill and delicacy of a watchmaker. They are taught to repair any sort of electrical instrument carried in a ship, to rewind or re-insulate a dynamo, or to put a torpedo in order however much it may be broken; and only those who have had practical experience of them can know what all that means, particularly when some instrument or circuit goes wrong overhead or in a tight place, and cannot or must not be moved.

Curiously enough, although these men constitute about the most valuable part of a ship's company, it has been decided to alter them, and consequently they are being done away with, and turned into chief armourers, so that one chief armourer in a ship may look after both torpedoes and guns. This is done with a view to reducing the number of rates carried in a ship, by making one man do the work of two, an alteration that could only be successful if men were made on a different model; but as it reduces expenses, and looks all right on paper, it answers its purpose. As is well known, the *esprit de corps* in the Navy is such that as long as only one man is left in a ship he will get through the work somehow; he is not able to spell "can't."

Torpedo Coxswains.

When torpedo boats were introduced, it was obvious that it would not do for any sailor to go on board and steer them, for they have peculiarities of their own which require learning, and their value is too great to allow men to be chosen at haphazard to steer them in and out of our crowded harbours. Accordingly the rating of T.C. was

brought in, and the manner in which the question was raised is amusing enough to be told. Mr. White, of Cowes, built a special steam launch for the Admiralty, and this boat was supplied to a ship in Portsmouth Harbour. She was very long, fast, and turned with amazing rapidity; after some experience of her, the captain of the ship represented that her coxswain ought to have a special rate of pay on account of his responsibility, for it is well known that when a boat steers exceptionally quickly she is more difficult to a novice to steer than an ordinary boat. This raised the whole question of steering torpedo boats, and a decision was come to that coxswains of torpedo boats were to be specially trained, and were to receive *6d.* a day extra pay; but on applying for one of these torpedo coxswains to be appointed for service in the special boat before mentioned, the captain was informed that she was not allowed one as she was not a torpedo boat! It may seem that *6d.* a day is a large sum as extra pay for the torpedo coxswain, but he has other duties to perform which place on him a good deal of responsibility. He is in charge of all the stores (except the engineers' stores) in his boat; he takes the place of a ship's steward in looking after the provisions and rum; the fresh water is under his charge, and he is responsible for the good order and discipline of the men; thus occupying a very high position for a bluejacket.

Besides going through a course of steering torpedo boats, bringing them alongside piers, and taking them to buoys, he goes through a torpedo course so as to have a thorough knowledge of how to get his torpedoes ready for firing. In many cases also the T.C. has an unacknowledged duty to perform, and one which requires much tact; as, for instance, when the naval manœuvres come on, sub-lieutenants are often appointed in command of these boats. The coxswain has often then to teach them how to manœuvre them,

and the usual way of arranging the routines, &c.; in fact, in many cases he is a dry nurse for the first few days, and yet is in every way an inferior to his charge.

General Remarks.

The above remarks do not by any means include the whole of the torpedo instruction in the service; and be it understood that torpedo instruction includes the following:

(*a*) Whitehead torpedoes.
(*b*) Mines for defence of harbours, together with the necessary plant for firing them.
(*c*) Electric lights.
(*d*) Accurate knowledge of high explosives, and how to best use them and safely handle them.
(*e*) How to best force an entrance into foreign harbours, requiring a knowledge of the means of defence employed by the different nations.
(*f*) How to manœuvre torpedo boats and destroyers to the best advantage by day or night.

Taking officers first, when a midshipman passes for a sub-lieutenant, he goes through a course of torpedo instruction which lasts four weeks. It is a very slight course, and to a great extent runs out of the young officer's brain as soon as his examination is over, but a certain amount sticks, and lays a foundation for more knowledge later on. Lieutenants are enabled, when they can be spared (which is not often), to go through a short course of instruction in the torpedo schools, and (if not appointed away before they have finished) they gain a considerable amount of knowledge in these subjects. Then there are also classes for commanders and captains in these schools (one class a year), not so much to teach them the technicalities as to give them sound ideas as to what can be done and how to do it. Officers in the R.N.R. are also encouraged to go through short courses; and here is at once

apparent how useful the training (however slight) is of a midshipman and sub-lieutenant. When an officer R.N.R. has served in a telegraph ship, he is found a very apt pupil, and takes but a short time to learn the technicalities of torpedo work. Sometimes also an officer R.N.R. has taken up electricity as a hobby, and then he manages to do himself credit; but where he has learnt the necessities of his own profession only, he may be and generally is an excellent seaman, but electricity, &c., is a *terra incognita* to him, and the result is not very satisfactory; for where you have an electric battery on the one hand and high explosives ready to be fired by electricity on the other, if the officer in charge is not thoroughly *au fait* at his job, a speedy dissolution is the probable result.

In addition to the above described courses of instruction, classes of officers and men are also held in our principal foreign ports when the ships are refitting; this instruction is almost entirely practical, and has been found to be most useful to the service.

The practical result of all this training is that, although torpedo work to be properly understood requires a good knowledge of such theoretical subjects as chemistry and electricity, yet these subjects are grasped even by bluejackets, and remembered by them. They may be seen of an evening studying the various text-books, endeavouring to get hold of the mysteries of hydrogen and oxygen, and the complicated evolutions of lines of force; and it is found by experience that when they begin to master these things, they go on trying to learn more about them, and read such technical papers as they are able to get hold of. The consequence is, that our torpedo service is as well served as any branch in the Navy, showing the truth of the *Vernon's* motto, "No difficulty baffles great zeal."

Symonds & Co.

Fig. 37.—H.M. Torpedo Depôt Ship "Vulcan."

CHAPTER X

TORPEDO DEPÔT SHIPS

Of all the various new types of war ships which the adoption of torpedoes and mines as weapons of naval warfare has brought forth, torpedo depôt ships are the most expensive and complicated. It is for this reason probably that our Navy does not possess many of them. It certainly cannot be due to any doubt as to the usefulness of this particular class of ship. Indeed, there is a consensus of opinion amongst naval officers that a properly equipped and self-efficient torpedo depôt ship is the most valuable adjunct that a fleet can possibly possess. The duty of such a ship is to serve as a movable base for torpedo boat operations, and to act as a floating storehouse and repairing shop for everything appertaining to torpedoes and mines throughout the fleet. In fact, the value of a torpedo depôt ship to a fleet cannot be over-estimated. Without her, the torpedo boats would be as chicks without their mother, and the squadron would be as a soldier without reserve ammunition. Not only does the ship guard and arm the torpedo boats and destroyers of the fleet, but she carries in herself a flotilla and mine store which is more than sufficient to play havoc with the best protected harbour to be found anywhere.

At the present moment there is only one torpedo depôt ship in the British Navy, her name the *Vulcan*. She is not the first of her kind, however, for the armoured steamer *Hecla*, until 1893, fulfilled this important duty, and, so far as her build and accommodation allowed, did it well. Probably no vessel in the whole service has her name so bound up with the history of the modern naval school as this old ship which is now laid up in ordinary at Portsmouth. Her captains have always been men noted for their skill and scientific attainmen's, and her officers zealous exponents of that department of naval warfare which they had chosen as particularly their own. The ship herself had little about her, so far as her construction was concerned, that called for special notice. She was built originally for the merchant service, and consequently was entirely unarmoured, whilst her armament of guns was very scanty. She carried, however, an enormous quantity of torpedo stores, and had fitted on board of her a small factory and repairing shop. She possessed, in fact, the qualification of being able to make other ships efficient without being efficient herself; and it was doubtless owing to this incongruous state of things that the Admiralty so wisely decided on building a vessel which on account of her construction and general fittings could be trusted both to look after her own self and at the same time act as a sort of torpedo nurse to any fleet to which she might be attached.

Both in outward appearance and inward construction the torpedo depôt ship *Vulcan* is unique. It is true that in different navies there are ships intended to fulfil the duties for which she was built, but none of them at present approach her in completeness of detail or perfection of design. A vast mass of delicate and intricate machinery, she is, nevertheless, thoroughly fit for all the tear and stress of warfare.

She is at one and the same time a cruiser, fighting ship, repairing shop, torpedo depôt, and floating dockyard. As a cruiser her capabilities extend to a cruising range of 10,000 miles at a speed of ten knots without any necessity for coaling; as a fighting ship she carries an armament of guns and torpedoes which would do credit to the largest cruiser afloat; as a repairing shop she possesses enormous lathes, drilling machines, planing, slotting and punching machines, circular saws, carpenters' and joiners' shops, blacksmiths' shops, forges, and blast furnace; as a torpedo depôt she carries a very large supply of mines and torpedoes of different patterns, and torpedo stores innumerable; and as a floating dockyard she possesses huge hydraulic cranes for hoisting in and out torpedo boats, and carries six of those vessels on her upper deck as a portable flotilla. In fact, every invention and improvement that engineers, constructors, electricians, and torpedoists could devise have been lavished upon her with unstinting hand, and she is without doubt from every standpoint the most remarkable vessel in the British Navy.

The first keel-plates of the *Vulcan* were laid down on June 18th, 1888, and a few days less than a year later she was launched, being of course at that time only in a very incomplete state. She is built of steel, and carries no armour with the exception of a turtle-back steel protective deck varying in thickness from five inches to two and a half inches at the lower edges. This deck, together with certain of the coal bunkers, protects the most vital parts of the ship, such as engines, magazines, and boilers. The length of the ship is 350 feet between perpendiculars, and the breadth 58 feet, the displacement 6,630 tons, and mean draught 25 feet. The machinery and boilers are capable of developing 12,000 horse-power, and were made by Messrs. Humphrey and Tennant, who also constructed all the auxili-

ary machinery with the exception of that for the derricks. The main engines are divided into two sets driving twin screws, and are triple expansion with overhead cylinders of 40-in., 59-in., and 88-in. diameter respectively. The condensers have a cooling surface of over 13,000 square feet, and the circulation of water through them is maintained by independent engines, which also actuate four pumps, each capable of drawing 1,000 tons of water per hour from the bilges. Four independent feed engines are fitted in the stokeholes for supplying water to the main boilers. In the engine-room, also, there are fire and bilge engines, turning and reversing engines, distilling pump, and a Normandy's condenser for supplying fresh water for the crew. The main boilers consist of four double-ended cylindrical ones 17 feet long and 14 feet in diameter, with three furnaces at each end. A smaller auxiliary boiler is also supplied for the dynamos, shafting, and miscellaneous engines. Forced draught is used, and the air for the furnaces is driven into the stokeholds by eight large fans, driven by a set of Brotherhood's engines working at about 500 revolutions per minute. The evils of forced draught were fully as prominent in the *Vulcan* as in other men-of-war, and the old trouble of leaky tubes broke out on board her very shortly after her being turned over by the builders. After several costly experiments, what is known as the "Admiralty ferrules" were fitted to the ends of the tubes, with fairly satisfactory results. It is a great pity that such a magnificent ship as the *Vulcan* is not fitted with tubular boilers; but unfortunately when she was built the great advantages of that type were only imperfectly understood and appreciated. It is more than likely, however, that her next set of boilers will be of the new pattern.

The contract horse-power of the *Vulcan's* engines under forced draught is supposed to be 12,000 i.h.p. As a matter

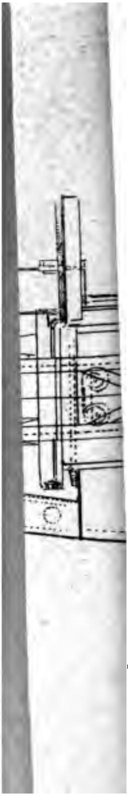
of fact, however, this has never yet been reached, owing to the wise decision of the Admiralty not to needlessly test the boilers to their fullest capacity. The ship, however, has acquitted herself splendidly on several occasions under natural draught. At the beginning of 1895 she was ordered to proceed at full speed natural draught from Volo to Malta for 48 hours on the way. She covered 850 miles in the 48 hours, which means an average of 17¾ knots per hour. The power averaged was 7,230 i.h.p., an excellent result considering the boilers are really in a make-shift condition, having been fitted with Admiralty ferrules. During the run no assistance was obtained from the deck; the engineers, artificers, and stokers being in three watches. The engines, it is reported, worked splendidly, with no water on any bearings except just a little on the guides to raise a lather. The average number of revolutions was 85. Altogether the trial was a thorough success, and clearly proved the *Vulcan's* right to be considered a first-class cruiser in the true sense of the word. Under forced draught the ship should go twenty knots.

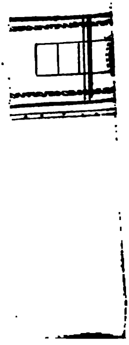
The hydraulic engines have an engine-room to themselves. They supply the pressure for the great cranes and bollards for hoisting in and out the torpedo-boats. They are in two complete sets and are of the ordinary horizontal tandem compound type. An hydraulic governor controls the supply of steam during the varying pressure of water, and another steam governor is connected with the throttle valve to provide against sudden breakdown and consequent racing. In these engine-rooms are also supplied the air-compressing engines and pumps for charging the Whitehead torpedoes with. What is called the "war dynamo" is also placed in this engine-room, the two others being above the protective deck. In such a hot and confined position as this war dynamo is in, it can hardly be expected

to acquit itself as well as those in more airy quarters; but in a ship like the *Vulcan* it is absolutely necessary to have one dynamo at least in a thoroughly protected position during action. These three sets of dynamos supply the electricity for the installation of incandescent lamps throughout the ship, and the four 25,000 candle power search-lights. The dynamos are of Siemens' pattern and are driven by Willans' engines, each dynamo giving a current of 400 ampères at 80 volts E.M.F., when driven at about 420 revolutions per minute.

The armament of the *Vulcan* consists of eight 4·7 in. quick-firing guns on the upper deck, four forward and four aft; twelve 3 pounder quick-firing guns on the main and upper decks; four fixed Whitehead torpedo tubes, and two launching carriages. The upper deck battery guns are fitted with protective shields and have a large arc of training, the bow and stern guns being able to bear on both sides. Thirty Whitehead torpedoes are supplied for serving the tubes with, those of the 18 in. pattern being used for one of the forward submerged tubes, and 14 in. for the remainder. Two of the fixed tubes are submerged, and two above water. A very large number of mines of different descriptions are also carried to be used by the ship herself, or supplied to other ships, as occasion may require. The *Vulcan* is also fitted with a powerful ram, but this weapon of offence is to a certain extent superfluous, as it is hardly likely that such a valuable adjunct to a fleet as a torpedo depôt ship would be used for ramming anything bigger than say a small cruiser or torpedo catcher, in which case a smaller and higher built ram would be amply sufficient. Some of the mines on board are charged with as much as 500 lbs. of gun-cotton and weigh 1,200 lbs.

But by far the most unique and interesting feature of





this wonderful ship is the gigantic system of hydraulic machinery and cranes for hoisting in and out torpedo-boats and lifting disabled torpedo-boats belonging to the fleet. As can be seen from the accompanying photograph two enormous goose-neck cranes rise from the ship amidships, looking almost big enough to capsize her by their overhanging weight. When first erected, these cranes drew a large amount of hostile criticism from seamen and engineers, who predicted that such an amount of top hamper would make the ship labour terribly in a sea way and be utterly useless for any practical purposes. As it happened however these fears have been completely belied, for the *Vulcan* is an excellent sea-boat, and when the cranes are trained outboard and loaded to their fullest capacity the list of the ship is comparatively slight.

These cranes, together with all their hydraulic arrangements, were designed and manufactured by the well-known firm of Sir W. G. Armstrong, Mitchell and Co., of Elswick. They are 65 feet in height, with a rake of 38 feet, and each weighs 27 tons. So great is their over-reach that the boats can be hoisted out clear of the torpedo nets round the ship, a most important consideration, since the work would always have to be carried on with the ship stationary and therefore in the position to use her nets to the best advantage, especially if the enemy's torpedoes happen not to be fitted with net cutters. No less than 30 feet of each crane lies bedded in the ship, passing down through the upper and protective decks to the double bottom, where the foot rests upon a large steel casting bolted to the ship's plates. That part of the upper deck which takes the chief canting strain is strengthened with a plain heavy steel ring without rollers, in which the crane rotates, the beams being also specially strengthened with steel plates and angles. So that the machinery may be well protected from

gun fire it is placed inside the pillar of the crane, the portion above the upper deck being protected with an armoured tube. The lifting machinery consists chiefly of two hydraulic rams, the larger one 17½ inches in diameter, and the smaller 5½ inches in diameter with a vertical travel of 10 feet, giving 40 feet at the purchase end through the multiplying power of the fourfold pulleys which are constructed to move to and fro in the usual manner. Of course this arrangement reduces the ultimate working pressure of the ram to one quarter of the original. Both pistons are rigidly attached at their upper ends to a large cross-bend which carries the upper four sheaves of the pulley, the lower four sheaves being at the lower end of the cylinders. The thrust exerted on the cross-heads by the rams is about 118 tons, but, as has been already explained, only one-fourth of their pressure comes available for hoisting. At first sight it may be difficult to see what good purpose can be gained by working at such a mechanical disadvantage, but it must be remembered that whereas an increase in hydraulic power only calls for slight increase of space, extra lifting power means a very large proportionate increase in the size of the cranes and tackle. If, too, the pulleys were double instead of quadruple, the hydraulic rams would have to be twice the present length. The hawser falls are made of steel wire 5½ inches in circumference with a tensile strength of 74 tons. The smaller cylinder already referred to is used for the special purpose of keeping taut the slings after they have been hooked on to the boat and until a favourable opportunity occurs for hoisting. The valves of the cylinder are so fitted that the pressure in the lifting cylinder cannot be applied until the smaller one is in action. Also as the boat rises on the waves the slings are *hauled* taut, and eased taut back as she falls again, the

pressure forcing the water through the bottom of the ram. By this means boats can be hoisted in or out in a seaway without straining either themselves or the cranes, through the slings suddenly jerking taut as the boat falls in the trough of the sea.

The cranes are guyed by the action of separate hydraulic machinery consisting of two cylinders fitted with rams 16 inches in diameter, having a direct thrusting force of 60 tons and placed vertically alongside the pillar of the crane. The reason for this large supply of power is due to the extra load which must inevitably be put upon the guy ropes when the ship is rolling, or when the list is enough to swing the crane towards the side. The rams actuate a 2⅛ inch chain cable which passes round a huge sprocket drum at the foot of the crane, thence over a pulley at the head of each ram, and the ends secured to the framing of the main cylinders. The cranes have a turning range of 250 degrees. A boat therefore can be hoisted up from alongside and placed in almost any position on the upper deck. All the torpedo boats carried on board rest in crutches fitted on trolleys moving upon rails, so that in the event of one of the cranes becoming disabled, they can all be brought, in turn, under the other one.

Before being turned over by the manufacturers, the cranes were subjected to severe tests. No less than 40 tons, or twice the proper working load, was applied, lifted 40 feet in less than thirty seconds, swung inboard and then outboard back into the water. The machinery worked splendidly and the droop of the cranes was very slight indeed.

Besides the two large cranes already described, an ordinary service derrick is fitted in the ship, actuated by hydraulic machinery of the same pattern as that for the cranes, but of *course of* smaller size, the working load

being 10 tons. This derrick is used for hoisting picket and rowing boats, mines, and other heavy stores. Four large hydraulic bollards, or winches, are also carried for use in connection with the derrick, and for general hauling purposes. The water pressure for all the hydraulic machinery is derived from two sets of horizontal tandem compound engines, working at 100 lb. pressure.

The torpedo boat flotilla carried on board the *Vulcan*, consists of six second-class torpedo boats built of steel, 60 feet in length, and with a speed of 16 knots per hour. The engines of each boat are of 230 i.h.p., the boilers being of the locomotive type usual in second-class boats. A large picket boat and steam-pinnace, both working with forced draught and closed stokeholes, are also carried, together with a small steam-cutter of ordinary pattern. Besides the steam-boats, there are several large open counter-mining launches, and the usual ship's equipment of cutters and smaller pulling boats.

Such is a brief description of what is by far the most remarkable and interesting ship in the British Navy. Since she was first commissioned by Captain Durnford, one of the most distinguished torpedoists in the whole world, she has undergone a large number of various improvements, the adoption of which could only be decided upon after a course of practical experience of the ship under seagoing conditions. With the exception of the trouble with the boilers, the ship has been, and is, an unqualified success, and a living tribute to the skill and cleverness of her designers. In war time no ship which we possess will equal her for usefulness. Whether in the Channel or Mediterranean, she will form the base from which the operations of our torpedo flotillas will be carried out. To her too will the fleet look for the sinews of war, when *protected* harbours have to be forced or destroyed. A

more important element in the fighting efficiency of a fleet could not be devised.

The French have also their torpedo depôt ship. The *Foudre*, such is her name, was inspired by our own *Vulcan*, and was launched in October 1895 at the Chantiers de la Gironde. She is smaller but longer than her English prototype, being of 5,875 tons, and 370 ft. long. Her beam is 52 ft. 6 in. compared with 58 ft. in the *Vulcan*. Her draught is 23 ft. 6 in. She is divided into a large number of watertight compartments, and her vital parts are protected by a steel deck with a maximum thickness of 3·5 in. The whole of the armament is quick-firing, and consists of ten 3·9 in., four 2·5 in., and four 1·45 in. guns. Like the *Vulcan* also, she is provided with powerful cranes and hydraulic apparatus for hoisting in and out the flotilla of ten aluminium torpedo boats which she carries in crutches on her upper deck. They are of the same pattern as the boat constructed by Messrs. Yarrow, which is described on another page. The *Foudre* will have engines developing 11,400 horse-power, giving a speed of 19 knots, and will carry 850 tons of coal. Her stores and equipment will be of a nature befitting the special purposes for which she has been built.

CHAPTER XI

TORPEDO BOATS

THE adoption of the mobile torpedo as a weapon of naval warfare was signalised by the advent of a class of vessel utterly unlike any which had hitherto figured in the navy lists of England or any other country. It was seen that in order to give torpedoes as wide a sphere of usefulness as possible, it was necessary to build vessels of such a type that they would be able to bring their torpedoes to bear in a way which combined the maximum of effect with the minimum of risk. The simple mode of firing torpedoes from large-sized ships presents few opportunities for using them advantageously. There can be no possibility under such circumstances of firing a torpedo into an enemy unawares, and indeed the only manner in which torpedoes can be used from a full-sized ship with any chance of success, is in open battle. Consequently a type of vessel was brought into existence which combined the qualities of great speed and extreme handiness, and was at the same time of such a size and shape as to offer the least possible target to the enemy. Such was the genesis of the torpedo boat, and since the time that this class of vessel was first built, designers, builders, and engine makers have succeeded in improving it to such an extent that the older forms of

boat may be said to bear as much resemblance to those now under construction, as the old paddle steamships do to the ocean "flyers" of to-day.

The earlier form of torpedo boat consisted of an ordinary steam cutter or steam pinnace fitted with a spar torpedo, and sometimes with a cradle on each side for carrying a Whitehead. In fact the boats were made to combine both methods. So far as the Whitehead torpedoes were concerned the boats were intended to fulfil duties which are nowadays relegated to the second class torpedo boats. They were to be used in protected harbours or roadsteads, or if at sea, only in very fine weather. At the time to which we are referring naval officers were, as it were, only gradually feeling their way in the direction of torpedo warfare. The possibilities of torpedoes were nothing like what they are now. In the first place, as has been pointed out in former chapters, the Whitehead torpedo, in its earliest form was exceedingly erratic and untrustworthy, and the choice as to what might be trusted to be the most effective and reliable form of torpedo rested fairly evenly between the spar torpedo and the Whitehead. On the one hand, the spar torpedo had been proved on numberless occasions to be capable of enormous possibilities, especially during the progress of the American war. On the other the Whitehead torpedo, though immeasurably superior in many respects, was as yet untried, and therefore to a great extent mistrusted. The merits of the Harvey torpedo had also to be considered, and also the towing torpedo. The very first boat which was ever built solely for torpedo purposes was one constructed by Messrs. Thornycroft of Chiswick for the Norwegian Government in 1873. The vessel was of exceedingly modest dimensions, being only 57 feet long by 7 feet 6 inches in beam, with a displacement of 7½ tons and 14·97 knots speed. She

was intended for using with a towing torpedo, a weapon which has now been rendered utterly obsolete. The boat herself, however, was rightly considered a triumph of construction and engineering. Her chief interest lies in the fact that even at the present day, that is to say twenty-two years after, she is still in existence, thus clearly proving that a boat though built of frail materials is not necessarily short-lived, provided those materials are first class and always well looked after.

But the year which witnessed the first real introduction of torpedo boats into the navy lists of the world was 1877. At that time the first English torpedo boat, the *Lightning*, was built by Messrs. Thornycroft, and no less than 100 boats were constructed by different firms for the Russian Government. The *Lightning* was delivered at Portsmouth in May of that year, but it was not until some time afterwards that a torpedo armament was placed on board of her, the tubes being fitted in 1879. This boat was 85 feet long and 11 feet broad, with a draught of 5 feet. Her displacement was only 27 tons, and her engines 460 horse-power with a maximum speed of 19 knots. A boat was built by the same firm for the Italian Government the year following, but she was not so successful as her English prototype being only capable of a speed of 18 knots. Like the *Lightning* she also was only fitted with spar torpedo gear. The one hundred boats ordered by the Russian Government were little larger than those now classed as second-class in our navy. They were 75 feet in length, 10 feet in beam, with a speed of 18 knots. These boats were constructed by seven different Russian firms, and Messrs. Yarrow, a firm of torpedo boat builders at Poplar, received orders for the supply of the machinery of as many of them as could be got ready before the closing of the navigation of the Baltic and for complete working

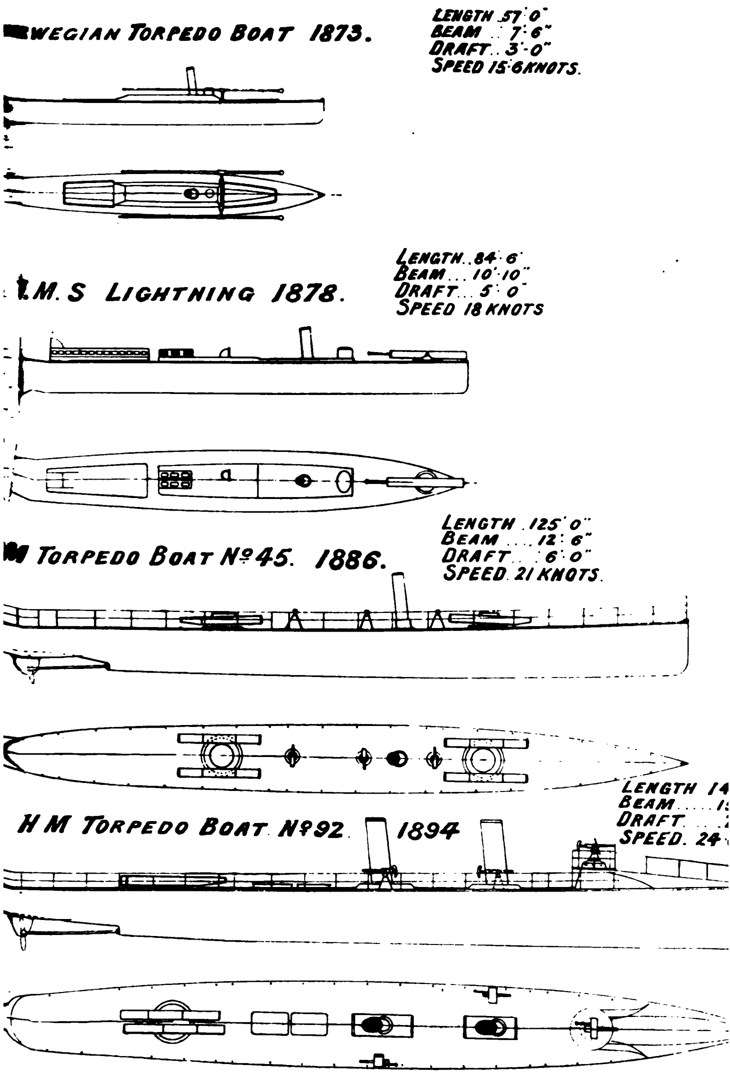


FIG. 39.—FOUR SUCCESSIVE TYPES OF TORPEDO BOAT.

drawings for the remainder. So quickly were these boats constructed that the first one was ready for its trials by the end of 1877. Mr. Yarrow has described how his boats were transported to Russia. Several of them, he said, "were forwarded by rail from St. Petersburg to Sebastopol with only the funnel removed to allow free passage under the bridges; they took a week in transport, and arrived in such good condition that immediately on being launched into the waters of the Black Sea from the railway trucks they were tried under steam with entire satisfaction and found to possess much better seagoing qualities than was anticipated." No wonder that after such a performance as that, foreign nations should look to us for the supply of their boats. Though this experiment of conveying boats by rail took place so many years ago it still conveys a most significant lesson to us, for it shows how easy it will be for Russia, when once her great Siberian Railway is finished, to concentrate a powerful torpedo flotilla in Far Eastern waters. Every other power except her, will have either to take their boats out there in sections—a laborious and unsatisfactory method of conveyance—or else let them risk the perils and uncertainties of a voyage of ten thousand miles. A voyage to Japan too, for instance, in a seagoing torpedo boat, under the most favourable circumstances now takes five weeks. By the Great Siberian Railway it would take a fortnight. That Russia will take every advantage of the facilities offered to her by her railway in this respect goes without saying.

So satisfied were the Admiralty with the performances of the *Lightning* that they forthwith commenced the ordering of torpedo-boats in earnest. In the autumn of 1877 and the spring of 1878 orders were given to different firms for the supply of twelve first-class boats with a

FIG. 40.—AN EARLY FORM OF TORPEDO BOAT.

maximum speed of 18·5 knots. The experiment was a great success, all the boats greatly exceeding their speed, and one of Messrs. Yarrow's attaining no less than 21·94 knots. The load carried during the trial was 6¾ tons, representing the dead weight of the armament, coal, fittings, &c. The next year, 1879, saw the completion of the first sea-going first-class torpedo-boat ever built. She was constructed for the Russian Government and named the *Batoum*. Her length was 100 feet and beam 12 feet 6 inches, not anything like so large as first-class boats are now, still a very decided advance on anything of the kind that had preceded her. Her engines were constructed to develop 500 horse-power, and on the official trial she attained a speed of 22 knots. She carried two fixed fore and aft tubes in the bow, and four Whitehead torpedoes worked from a forward armoured conning tower. The boat was also fitted with masts and sails as a reserve in the event of breakdown. That her claim to be considered a sea-going torpedo-boat, in the true sense of the term, was a correct one, was evidenced by her voyage with a crew of three officers and nine men from London to Nikolaief, a distance of 4,800 miles, at an average speed of 11 knots. There can be little doubt that the remarkable performance of this boat was a leading cause of our Government as well as several foreign ones eventually adopting the systematic construction of first-class torpedo-boats.

For the next few years the British Government, for reasons best known to itself, held its hand in the construction of first-class boats. Perhaps it was partly due to the fact, that, about that time it was the fashion to decry the merits of the Whitehead torpedo amongst a large number of our naval officers, or certainly there was a general decided scepticism as to its use in the

open sea. At any rate the omission to arm ourselves with sea-going torpedo-boats could not justly have been due to any belief that vessels of that size were unable to keep the sea for any length of time. As a matter of fact four boats built in 1880 for the Argentine Government accomplished a voyage to Buenos Ayres with hardly any difficulty whatever, one of them reaching that port from Plymouth in twenty-two days. In a letter which the captain of one of them addressed to the builders, he said: "I have no hesitation in saying that their sea-going qualities are exceptional. On both voyages we encountered very rough weather, and in the case of the *Brazilian* we were laid off Cape Frio in a heavy S.S.W. gale of such a force I have not experienced the like for twelve years, and she behaved admirably." Surely a remarkable performance for a boat of 40 tons. Yet although our Government showed such reluctance to build first-class boats they attempted to effect a compromise by ordering in 1880 no less than thirty-four second-class boats for harbour work, and for carrying on the decks of cruisers and battleships. These little vessels are about 60 feet long by 7 feet to 9 feet broad, with a displacement of 17 tons, and of about 200 horse-power, giving a speed of 17 knots. They each carried one machine-gun and two torpedoes which were hung one from each side by an arrangement of davits and cradles. This mode of firing has however now become quite obsolete, and in its place is fitted the boat's dropping gear, described on another page. In the former arrangement the boat had to be brought to a state of rest before the torpedo could be fired; in the latter, as has been explained, no slackening even of the boat's speed is necessary.

From 1880 to 1885 the British Government steadily refused to add more first-class boats to their navy list, and

this in spite of the fact that foreign governments were constantly adopting them, and that our boats were gradually wearing out. In 1884 matters stood as follows. Russia possessed no fewer than 115 boats, France 50, Holland 22, Italy 18, Austria 17, and England 19. This meant that Russia possessed one boat for every 18 miles of coastline, France one boat for every 33 miles, and England one for every 197 miles, or, including the colonies, every 800 miles! These startling and interesting facts were brought forward in a paper by Mr. Yarrow at the Royal United Service Institution during the year in question. The paper, read as it was by a man who was in every way an expert on the question, caused considerable sensation at the time, and called forth a lively discussion on the part of several officers who were present when it was read. Lord Charles Beresford, who took the chair at the meeting, remarked significantly that not a single naval member of the Admiralty, or any naval officer, denied the urgent necessity for more torpedo-boats. What was wanted first, however, was money, and that, apparently, the Chancellor of the Exchequer refused to supply. The same story has been told over and over again in subsequent years, but to the credit of England, both the Government and the country has at last awakened to the fact that parsimony where the Navy is concerned is foolishly suicidal, and if appearances go for anything it will be many a long year before we again forget the existence and value of our Navy as we did between the years 1880 and 1885.

This lecture and the discussion which followed it would appear to have acted as a lever for lifting the Admiralty from the lethargy which it had fallen into for the past few years, for a month or two later the building of first-class boats began again as suddenly as it had ceased, two being forthwith ordered from Messrs. Thornycroft, and two from

Messrs. Yarrow. No sooner were the first two boats completed than they were ordered to join the Manœuvre Squadron under Sir Geoffrey Hornby, which was mobilised in the summer of 1885. Besides the two new boats, six others were told off to accompany the fleet. As might well have been expected, these six old boats cut a sorry spectacle when bad weather came on. For four years they had been run at intervals training stokers and coxswains, or acting as vehicles for picnic parties and other useless purposes. When not actually in use they were allowed to rot and rust in the dockyard ports, with scarcely enough attention devoted to them to keep them clean, let alone in proper repair and working order. The boats, in fact, had been looked upon more as experimental playthings than as efficient units of naval force. The result was that they proved veritable "lame ducks" during the manœuvres of the year in question. Not only were they hopelessly deficient in speed and general seaworthiness, but the crews themselves were totally untrained in their use, and were consequently miserably seasick, and loth to keep at sea in them for any length of time. It is true these particular boats were not quite so large as those that had crossed the Atlantic and weathered gales and heavy seas with scarcely any damage to themselves. The differences in displacement and horse-power, however, was not so great as to account for their being so immeasurably inferior to the foreign ones, and there can be no doubt whatever that the causes of their bad behaviour on the occasion in question must be traced directly to the reasons already described. The two new boats acquitted themselves far more satisfactorily, and with the exception of a few minor breakdowns in the engine-room department, stood the wear and tear of the manœuvres very fairly well.

During the year 1885 no less than fifty-four first-class

torpedo boats were laid down, and two more were purchased. Twenty-seven were constructed by Messrs. Thornycroft, twenty-two by Messrs. Yarrow, and five by Mr. White. The two purchased ones had been built for the Russian Government, and were only 100 feet long. The first four of the others to be completed were only 113 feet long, but the Admiralty very wisely decided to increase the dimensions of the remainder by about fifteen feet, so as to render them more seaworthy. Twenty of the boats, numbered 41–60, constructed by Messrs. Thornycroft, are of the type illustrated by No. 45 in the diagram. Their length is 127·5 feet, with a beam of 12·5 feet, and a maximum draught of 6 feet. Their maximum speed (on the trials) was 21 knots, and their engines were capable of developing, under forced draught, 700 horse-power.

These Thornycroft boats have proved themselves by their behaviour and performances of the past ten years to be most thoroughly good little vessels. Their distinctive feature is a perfectly flush deck from stem to stern. On glancing at one of these boats from the outside, it would be hard to understand how a crew of three officers and thirteen men could possibly live on board of her with any degree of comfort, at least for any length of time. Yet practical experience has shown that life on board one of these little craft is, to say the least of it, quite bearable. In the mess-deck forward there is room for all the men to lie down at full length on their cork mattresses, the chief engine-room artificer having a private little berth of his own. The officers' quarters are also very decently comfortable, the ward room having a little pantry outside, and four cushioned lockers with a table and cupboards inside. Enough head room is also given to enable a moderately tall man to stand upright below deck. Each of these boats carries an armament of two three-pounder quick-firing

Symonds & Co.

FIG. 41.—FIRST-CLASS TORPEDO BOAT NO. 79.
(At one time commanded by H.R.H. the Duke of York.)

guns and four torpedo-tubes with two torpedoes. The war heads for the torpedoes are kept in the after compartment, and the ammunition for the guns in store compartments under the mess-deck. The dynamo for the search-light on deck is placed, as in the case of the destroyers, in a little compartment containing the boat's galley. The boat is conned either from the deck or from the inside of one of the two little armoured conning-towers which are placed one forward and one aft. As a matter of fact the conning-towers would never be actually occupied by the captain or officer of the watch, except in action or in intensely cold and heavy weather. The steering-wheel of the forward conning-tower is brought outside by fixing it at the end of a steel bar connected up to the wheel and tiller ropes inside, and the helmsman on deck stands protected from the wind and sea by the conning-tower in front of him. If necessary a canvas weather cloth is rigged up on top of the conning-tower to still further shelter him.

The chief distinctive feature of the Yarrow boats of that date is a raised "turtle back" running down from the fore part of the forward conning-tower to the stern. The advantage of this arrangement is that extra head room is given for the men forward, and allows for a raised deck underneath, beneath which are water-tight compartments for the storage of stores and ammunition. In other respects the Thornycroft and Yarrow boats built during the year in question are pretty nearly similar. The question as to the relative merits of a flush deck, or one broken into a "turtle back" forward, is a matter of purely individual opinion. Whereas some officers consider that a perfectly free run along the whole length of the deck of a torpedo boat is a great advantage, others aver that the turtle back makes the boat far more seaworthy and capable of standing the strain of a head sea. With regard to the latter con-

tention, however, it must be borne in mind that in thrashing against a heavy head sea, the part of the boat which receives the greatest number of blows is not the fore part of her upper deck so much as that about her foot and entry. On meeting a heavy sea end on, if going at a good speed, the boat plunges partly through it, bringing her bow right out of water on the other side of the wave, and falling with, what may be described as, a thundering smack into its trough. A certain part of the blow comes of course on to the deck, but it comes from the crest of the wave and not the body of it. It is fortunate that the lines of the boat prevent the stern rising as much out of the water as the bow, for if it did she would soon shake herself and her engines to pieces. In the Thornycroft boats particularly this danger is almost entirely obviated by the peculiar construction of the stern. In this case the propeller is inside an overhanging counter which draws up the water with it as the stern rises, thus keeping the propeller always immersed. This excellent arrangement is also followed in principle in the case of the destroyers built by the same firm. So far as the design and workmanship displayed in the general construction of the boats is concerned there is nothing to choose between Yarrow's or Thornycroft's, and the same may be said of Mr. White's boats.

The sudden and unmistakable decision of the leading naval power to adopt torpedo boats as serious weapons of warfare had the inevitable effect of startling all the European navies into further expenditure in this direction. In 1885 and 1886, torpedo boats, both first and second class, were built by Austria, Chili, China, France, Greece, Italy, Portugal, Russia, Spain, Sweden and Turkey. The United States still stolidly refused to take a lesson from the old world, and for reasons best known to herself,

refrained from building anything more than one experimental second-class boat. It is true she had not then adopted the Whitehead torpedo; still the Howell, with certain restrictions, was adaptable for boat work. In any case it is very curious that the Power which has had more practical experience of torpedoes in actual warfare than any other, should be the least enterprising regarding them to day.

It is impossible within the scope of this work to enter upon the distinguishing features of the different boats built abroad or in England for foreign nations at that time, but an exception must be made in the case of a boat built for that rising nation in the Far East, which in a few years was to startle the whole world into sudden recognition of her position as a first-class Maritime Power. Japan was then being schooled by European teachers, and the English naval officers who guided her policy at sea had already, many years before, impressed upon her the necessity of building sea-going torpedo boats. Now, in 1885, they once more caused their pupil to show a fresh example to the naval powers by building a vessel which is unique of her kind, namely an *armoured* first-class torpedo boat.

This boat, the *Kotaka* by name, was made by Messrs. Yarrow, and was the largest ever built up to that time, being 166 feet in length, with 19 feet in beam, and her engines, which are of 1,400 horse-power, enabled her, in spite of the weight of armour, to attain a speed of nearly 20 knots per hour on trial. All the vulnerable parts of the vessel, including the machinery and boilers, are protected by one-inch steel armour-plates. This is quite sufficient to keep out bullets from machine guns, except on those infinitely rare occasions when the firing would take place at very close quarters and the hits would be direct instead of at an acute angle. Her armament consists

of four machine guns and six torpedo tubes. Two of the latter are placed right forward and fixed for right ahead firing, while the others are mounted as two pairs of revolving tubes, one pair amidships, the other aft. The boat has also a long ram. The most interesting part about the *Kotaka,* however, is the prominent part which she took in the late Chino-Japanese war. In the words of a Japanese officer on board of her, "it was she that led the torpedo flotilla in their daring entry into the harbour of Port Arthur, at the nick of time, which called forth the admiration of the British officers on board the *Porpoise.*" The fact that the boat led the attack clearly showed the entire confidence placed in her by the Admiral in command and the slight loss of speed entailed by the extra weight of armour appears to have been more than compensated for by her comparative immunity from destruction. It is more than probable that the Japanese will take their lesson to heart and give orders for a further supply of vessels of the same type as the *Kotaka.*

The year 1886 marked a lull in torpedo boat building for this country, though more activity in that direction was observable abroad. On the other hand the sudden advent of so large a torpedo flotilla into the navy had the inevitable effect of rousing the authorities and the whole service into a more careful study of the advantages and disadvantages of torpedo boat warfare and many valuable though often misguiding lessons were learnt this year both at home and abroad regarding it. The fastest vessel at that period was the *Ariete,* built in England for the Spanish Government; her speed on the trial was no less than 26·18 knots. High speed amongst foreign boats was indeed one of the predominant features of the year. A boat built for China reached 23·9 knots on the measured mile; the firm of Schichau which had then made a speciality of torpedo

N 2

boat building constructed several boats of 23 knots for Russia; and a Turkish boat, engined by Maudslay, attained a maximum speed of 23·4 knots. France launched nine first-class boats, one of them reaching a maximum mean speed of 23 knots.

But by far the most interesting feature of 1886, so far as torpedo boats were concerned, was the lesson afforded by the result of the French manœuvres held that year in the Mediterranean. It was proved, so it was considered beyond a doubt, that for boats to be classed as sea-going in the proper sense of the term they must be over one hundred feet in length, and their crews more thoroughly exercised in the control of them. The weather during a certain part of the time was more than enough to tax the capabilities of the boats and their crews to the utmost. In bad weather no more than 10 knots could be maintained, as the boats plunged and raced to such an extent as to cause a reduction of speed simply imperative. On the other hand, when fine weather prevailed, better results were obtained, several of the ironclads (according to the accounts of the attackers) being torpedoed by the boats. In these manœuvres, as in all subsequent ones, there was the usual controversy as to whether the ships had been torpedoed or not, and consequently the verdicts of the umpires cannot be taken as infallible. Four important conclusions, against which there then appears to have been little cavilling, were deduced from the manœuvres in question. The boats, it was argued, were unable to drive off a squadron besieging a town; they did not succeed in breaking a blockade; they were of little use when attacking a harbour protected by heavy guns; and, as has been already pointed out, much larger boats were considered to be undoubtedly required for open sea work.

In the face of such results as these it is perhaps not sur-

prising that both the British and French Governments held their hand for a time in the construction of ordinary first-class torpedo boats. Instead of boats, both ourselves and our neighbours began to build vessels of such dimensions that they could act *to a certain extent* the part of torpedo boats, and yet be qualified to accompany or harass a fleet in all conditions of wind and weather. Torpedo "catchers" and gunboats were then the order of the day, and torpedo boat building for 1887 was confined to a solitary one for each Power, though these were in each case considerably larger than their predecessors. The French manœuvres of 1887 also only tended to confirm the opinion of the authorities regarding the unfitness of ordinary first-class boats for the open sea, two of them being actually thrown on their beam ends and nearly lost, and the crews being continually *hors de combat* from sea-sickness and exposure.

Yet paradoxical as it may seem, both the French and ourselves were entirely mistaken in our deductions. By increasing the size of the vessels we were departing from that inviolable rule regarding torpedo boats—namely, that they shall be of such a type that they can bring their torpedoes to bear in a way which combines the maximum of effect with the minimum of risk. One of the chief reasons for the adoption of torpedo boats as units of naval force was their smallness of size and comparative immunity from destruction. Increase their size to a very great extent and their chief element of protection is taken from them. It must be remembered that the larger vessels which were begun to be built about this time were only "catchers" in name. The chief duty which their designers intended for them was the work originally intended for torpedo boats; indeed the actual reason for their adoption was that torpedo boats were considered as being unable to keep the seas, in which case there could be no

torpedo boats at sea for them to catch. The fact too that the crews were in a short time totally incapacitated for work, ought surely to have been no reason for increasing the size of the boats to such an exaggerated extent. The proper course would have been to set to work to train officers and men for a particular branch of naval service, and subsequent years have shown us plainly how easily this can be done. Again, the rolling and general unseaworthiness of the boats did not necessarily mean that they were too small. Rather it meant that they were built on wrong lines, or at any rate that another twenty feet or so would make all the difference. Practical evidence of this can be seen in the English boats built in 1885, which are still fit for hard work and have weathered far worse storms than the Frenchmen ever saw during the manœuvres of 1886–87.

Only one torpedo boat was added to the strength of the Navy in 1887, namely No. 80, a fine boat 135 feet in length, and the best of her kind up to that time in our service. Her maximum speed of 23 knots however compared rather unfavourably with some of the boats built abroad. In 1888 no torpedo boats whatever were launched for us. The naval manœuvres of that year, however, served to remind the Admiralty that they were once more lagging behind the other Powers in this particular department of ship-building, for in a report of the Committee that was appointed to consider and report on them, opinion was expressed that "in comparing the torpedo flotilla of England with those of other great Powers, the Committee are of opinion that in this respect this country is not as strong as it should be." This report, signed as it was by such officers as Admirals Sir William Dowell, Sir R. Vesey Hamilton, and Sir Frederick Richards, had only one possible result, namely a further increase in the strength of

our torpedo fleet. Accordingly, an order was given to the contractors for six first-class boats and ten second-class ones. The latter were intended for carrying on the decks of battleships and torpedo depôt ships, and for work inside protected harbours. The first-class boats built that year are 130 feet long, 13·5 feet beam, with a draft of 5·5 feet. Their maximum speed on the trials was 23 knots with an I.H.P. of 1,100. The French manœuvres of the same year, although they were attended by the capsizing of one boat and the loss of another, appear to have served to modify the objections hitherto held in that country against torpedo boats, the Committee appointed to report on the same holding that the results tended to prove the necessity of supplementing the land defences with submarine defences and torpedo boats. In consequence of this report a very large number of both seagoing and first-class boats were ordered, their production extending over three years.

During 1889 all the Yarrow boats, both first and second class, ordered the year before, were launched. The Navy thus possessed eighty-four first-class boats and seventy-two second-class ones of various degrees of efficiency. This supply was exclusive of the twelve boats owned by the different Colonies and the seven new boats just acquired by the Indian Government. Three of the latter were particularly fine little craft, being 134 feet long and capable of steaming 23 knots at a push.

The French boats classified as "seagoing" are really only first-class boats of a large type and of high speed. In fact they are about half-way between an ordinary British first-class boat and a destroyer. The original one was the *Coureur*, launched in 1888 and built by Messrs. Thornycroft, at Chiswick. This boat, which was taken as the model for many subsequent ones, is 147·5 feet long, 14·5

West & Son.

feet in breadth, with a maximum draught of 4·6 feet, a remarkably small amount for so large a vessel. Her full speed on the trial was 24·5 knots, a result which few of her successors succeeded in attaining.

Although France and other nations pushed on their torpedo boat building with energy during the next three years, the British Government on the other hand entirely ceased doing so, and instead devoted their attention to what they considered a better type of vessel, namely "catchers." As is explained however in the chapters dealing with those craft, the high hopes which their designers held regarding them were doomed to bitter disappointment. England in fact, it is now generally admitted, was entirely on the wrong tack in her torpedo boat policy during those three years, and while other nations were arming themselves with efficient torpedo flotillas we were standing still through our stubborn infatuation for a class of vessel which we fondly imagined was altogether superior to the torpedo boat, but which eventually turned out to be a hopeless failure. It is lucky for us that Europe and ourselves were at peace during that period. Yet although during this time we held our hand so far as the actual building of torpedo boats was concerned, we were nevertheless learning many useful lessons regarding them. The supply of boats which we possessed was not so small or so inefficient that valuable instruction could not be gained regarding the handling and disposition of them.

The naval manœuvres of 1890 were a fiasco so far as concerned the two fleets of battleships and cruisers which took part in them, for they never sighted one another once during the whole time. But most valuable lessons were learnt from the operations carried out by the torpedo flotilla under Commander Barry, whose head-quarters were at Alderney. Without going into all the details of the

operations, it may be said that two important deductions were made from them. One was that the efficiency of torpedo boats depended almost entirely on the amount of practice which the officers and men on board of them had had in that particular branch of work; and, secondly, that an ordinary first-class torpedo boat if properly manned should be able to keep the sea if necessary for three days without coaling or watering; that is of course providing the boat is not running the whole time, but only at intervals.

But what showed the possibilities of even moderately-sized boats to the greatest advantage during this year was the voyage of Nos. 61 and 62 across the North Atlantic. They were convoyed by the storeship *Tyne*, but that ship appears to have had enough to do to look after her own safety let alone that of her unfortunate charges. The voyage of these two boats was vividly described by an officer on board one of them shortly afterwards in the *English Illustrated Magazine*, and it is no exaggeration to say that his story is one of the most exciting that has ever been written about the sea whether in history or fiction. The two boats which accomplished this eventful voyage are first-class ones, built by Yarrow in 1886, and are 125 feet long by 13 feet broad at their widest part. Their internal construction differs but little from the Thornycroft boats described on p. 174, and it will be easily understood therefore that the stowage room on board of them was none too ample. They left Plymouth with the *Tyne* at midnight on June 13th, and on reaching the Land's End at once fell in with a heavy sea, when their troubles began. Although the crews were composed entirely of picked men, nearly the whole of them were at the outset violently sea-sick, and it was some time before even the labour of keeping the boats afloat and going,

succeeded in driving them, as it were, into recovery. The rolling was simply awful, the boats often being half under water. Everything that was not actually built into the boat was wrenched from its fastenings, and sleep even when wedged up between boards and blankets was a practised art. Feeding was also a rough and tumble business. Indeed, a few days' existence in a torpedo boat, even under less trying conditions than those referred to, creates a curious tendency amongst the crew to revert to the pre-historic condition of man when he lived like a wild beast, ate his food with his fingers, and never indulged in the luxury of a wash unless it was an involuntary one. A quotation from the officer's account will explain how this is: "As a rule," he said, "we lived on ham, sardines and tinned soups; for most of the time the weather was so rough it was as much as we could do to get a little water boiled. We had a table about eighteen inches wide in the cabin, but it was no good having it laid, for nothing would stay on it. The usual plan was for one man to hold the sardine tin while the other picked out sardines by their tails and transferred them to his mouth. Ham always required two men, one to hold it and the other to cut it." But these little peculiarities of living were only by the way. What engrossed the attention of the officers and men throughout this dreadful voyage was the task of keeping their vessels afloat. Now and then a diversion was gained when the boats ran under the lee of the *Tyne* for a fresh supply of coal, an evolution attended with a considerable amount of danger. But worse was to come.

For a whole week after starting the weather was one furious gale. On June 20th, the rising of the barometer held out a hope of better times, but it was only a passing fancy on the part of the clerk of the weather, for the

next day found the wind and sea worse than ever. Had it not been for the oil which was poured over the stern of the *Tyne* there appears to be little doubt but that the boats would have foundered. Stanchions were smashed, deck gear was washed clean overboard, and most serious of all, a rivet in the fore compartment of one of the boats started, with the result that the lower deck was flooded; fortunately, however, the transverse bulkhead stood the strain. At length, however, the gale subsided, but even worse dangers now awaited the boats. After a two days' good run they found themselves amongst the icebergs, and in a thick fog. So bad did the latter become that they had to turn round and steam eastward again until it lifted. The icebergs, too, were a most serious source of danger, and it was little short of marvellous that the *Tyne* and the boats did not all come to grief amongst them. At last early one morning St. John's harbour was sighted, and the torpedo boats' troubles were over. As the officer who recounted their adventures said, there they were at last "battered and weather-beaten, their paint all gone, their stanchions bent, broken, twisted, and gone altogether; funnels caked with white salt, everything smashable smashed; very different were they from the trim boats which left Chatham on a sunny morning in June." It has often been asked why were the boats sent across the Atlantic by such a northerly route. Their course was as dangerous a one as could possibly be picked out, for 'cebergs and thick fogs are always found off the New- oundland coast in June and July. Be that as it may, this 'emarkable voyage, though it was terribly trying to those who accomplished it, afforded startling testimony to the seagoing qualities of moderate-sized torpedo boats when manned by officers and crews of good physique. Certainly the performances of Nos. 60 and 61 were in striking con-

trast to those of the French boats during the manœuvres of the year before. Since the year in question, torpedo boats have been sent out by us to our naval stations in Australia, Hong Kong, Singapore, India, and the Mediterranean, and all have accomplished their voyages without serious mishap.

At the end of 1890 the different Powers possessed the following number of torpedo boats built, building, or projected :—France, 210; England, 206; Germany, 180; Italy, 152; Russia, 143; Austria, 61; Greece, 51; Holland, 50; Denmark, 34; China, 32; Norway and Sweden, 31; Turkey, 30; Japan, 24; Spain, 15; and Brazil, 15. The United States during that year commissioned their first torpedo boat, the *Cushing*. Six splendid first-class boats were also built at this time for the Argentine Government. They are 130 feet long and fitted with quadruple expansion engines. On the trials one of them during a continuous run of two hours, with full load on board, attained a speed of 24·45 knots, being one knot faster than similar boats fitted with triple expansion engines. The turning power at full speed was found to be within a circle the radius of which was equal to the length of the boat, without producing any appreciable angle of heel. By the peculiar arrangement of the machinery the vibration was reduced to a minimum. The Argentines also at the same time acquired eight second-class boats fitted with tubular boilers, which succeeded in going 18 knots with a load of two tons on board.

During 1891 no torpedo boats, either first or second class, were added to the strength of the British Navy. The Admiralty still imagined that the great lesson to be drawn from the manœuvres of this and former years was that "catchers" were the proper type of vessel to build, and not torpedo boats. In holding this opinion, however, it

embered that they were guided by several ...ny erroneous assumptions. In the first place, one of most stringent rules of the manœuvres carried out in t year was that ships protected by torpedo nets were to considered invulnerable so far as torpedoes were con-ned. Now it is a well-known fact that torpedo nets are nearly useless for purposes of protection either in bour or at sea. Net-cutters are, at the present day, ...d by certain Powers which have adopted the White-ead torpedo, and even in 1891 it must have been perfectly well known to the authorities that the net-cutter invented by Captain Wilson could part the toughest net in the service. The nets too, as has already been explained on page 90, were actually a source of weakness and hindrance to the ships using them. Yet in spite of all this the fiat went forth that it was practically useless for a torpedo boat to fire her torpedo into the nets of the enemy, even if the latter was completely taken by surprise and had had no time to fire her guns with any effect. How utterly misleading was this rule may be gathered from some of the bare results of the manœuvres in question. On the night of the 25th the *Northampton* and *Shannon* were attacked by torpedo boats and were torpedoed. *The ships had their net defences out, however, and the claim of the torpedo boats was disallowed.* On the night of the 29th again the same two ironclads were attacked by torpedo boats, who each delivered a torpedo into their opponent's nets before they had been under fire sufficiently long to be disqualified. Again the umpires decided that *the two ironclads were not sunk because their net defences had been rigged out.* Here we have an example of two important ships being saved from destruction on two distinct occasions, simply because they had protected themselves with apparatus which really constituted hardly any protection at all.

Again, another important rule of the manœuvres was that torpedo boats who were under fire for a certain short space of time, from the ships they were attacking, were to be considered out of action. There was no provision made that the guns should be properly laid, or that the umpires should take into consideration the chances in favour of the torpedo boats on account of the confusion and uncertainty reigning on board the ships which were being attacked. As a matter of fact whenever a torpedo boat attack was expected, the guns were kept ready loaded, and directly the cry of "torpedo boats coming down" was raised, the captains of the guns were expected to blaze away at once. Aligning the sights at the supposed enemy was a matter of quite secondary importance. The chief thing was to blaze away, and blaze away as fast as they could directly the alarm was raised, so as to bring the torpedo boats "under fire" at the earliest possible moment. On more than one occasion, and notoriously so on the night of the 29th, several of the ships were actually firing right into their friends, and it is more than probable that if the guns had been properly loaded the ships in harbour would have done far more damage to themselves than any of the enemy's torpedo boats could have inflicted on them. Captain Durnford, than whom no better authority could be found, and an exceedingly practical officer as well, gave it as his opinion that as regards a night torpedo boat attack, "the accuracy of the fire of guns has to be considered," and considering "the extraordinary way people think they see torpedo boats when none are there," he thinks that "the boat has an excellent chance of not being hit." The same great authority also pointed out that "the accuracy of gun fire depends upon the distance being known to give the guns the required elevation. The accuracy of torpedoes does not depend on this."

Another prominent feature of the manœuvres of 1891 was the lamentable performances of the torpedo "catchers." On the evening of the first day the *Rattlesnake*, one of the fastest of her kind, signalled three of the enemy's torpedo boats, and chased them for several hours without being able to come up to them. Next morning again the "catchers" chased three torpedo boats, two of which escaped, and the other was captured through her steering gear breaking down—a wondrous victory indeed! The same day three other boats were chased again by the "catchers," but escaped. On the 24th a torpedo boat which had injured her propeller and was consequently only able to crawl along, was pounced upon by the gallant *Rattlesnake*. During the course of the same day a duel was fought between three torpedo boats and the *Gossamer*, and each side claimed the victory; the umpires, however, gave it to the "catcher." On the evening of the following day a torpedo boat succeeded in torpedoing the *Northampton*, though that ship had a "catcher" mounting guard over her. The same night the *Spider* encountered five torpedo boats and claimed to have captured the whole lot. This however was too big a pill for the umpires to swallow, and the claim was disallowed; on the other hand, though the circumstances under which the "catcher" found herself would have been hopeless in warfare, she was not given to the boats as a prize. In the afternoon of the 27th, three boats under Lieutenant Bayly cleverly hemmed in the *Gossamer*, and claimed to have captured her. Of course a counterclaim was made, but again the umpires refused to sustain the latter, though the torpedo boats were adjudged out of action for twenty-four hours. The same kind of action took place the next day with the same results. This was the last encounter between the "catchers" and torpedo boats. The sum total of the former's wins therefore for the whole manœuvres amounted to two torpedo

boats, both of which had been previously disabled and were consequently unable to defend themselves properly, and three boats which certainly gave the "catcher" as bad a dressing down as she gave them.

It is curious, in face of these poor results, that the authorities should have still persisted in their love for "catchers." On the other hand it was hoped at that time that the improvements which were then being carried out in that class of vessel would result in increased speed. As is pointed out elsewhere, however, that hope was doomed to bitter disappointment.

This same year extensive torpedo boat operations were carried out by Russia and France, but in both cases, and in the former especially, the results of the manœuvres were almost valueless for drawing conclusions, on account of the way in which the rules were framed. For instance, the Russians held that a torpedo boat was destroyed if it had been "fired on" from a distance of seven cables by one machine gun for three minutes, two or three machine guns for two minutes, and four or more guns for one minute; whilst if a vessel was simultaneously attacked by several boats these times were to be increased by one minute. This meant, for instance, that if an iron-clad was attacked by four or five torpedo boats coming down on her from different directions, she would be able to sink them all if she kept them under fire for two minutes! Any one who has been on board a ship which is being attacked at night by several torpedo boats can realise the absurdity of such a rule. What with the darkness, confusion, and general panic, it is doubtful if even one boat could be stopped in the time, let alone the whole lot. There was one important particular, however, in which the Russians differed from us on this occasion in the framing of their rules. Vessels with nets out were to be considered

out of action if two torpedo boats succeeded in approaching within two cables simultaneously without being observed; which showed that the foreigners did not put such faith in the absolute invulnerability of a net-protected ship as we did. In any case, whichever country was right, these discrepancies in the rules governing their manœuvres detract very much indeed from the value of a comparison of them.

The year 1892, like the one preceding it, witnessed no additions to our Navy in the shape of torpedo boats, although twelve more were ordered. The Admiralty were still continuing to build "catchers" of larger dimensions than hitherto, thereby departing still further from their original policy of building torpedo craft which combined the minimum of size with the maximum of speed. At the same time there was evidently considerable doubt exercising the minds of the authorities regarding the wisdom of the policy they were pursuing, for although they still continued to abide by their hobby they compromised matters, and at the same time showed their indecision, by entering upon the construction of twenty vessels of an entirely new type, namely, torpedo boat destroyers. For this reason, 1892 is a very important period in the history of torpedo craft. It marked the practical though tardy abandonment of a wrong policy of shipbuilding for a right one. As has been also mentioned twelve more torpedo boats were ordered this year from different firms, the Admiralty wisely announcing their intention of making a certain addition each year to the flotilla of torpedo boats. The vessels ordered this year are a decided improvement on their predecessors. Their length is 140 feet, beam 15·5 feet and draught 7·3 feet. The engines are triple expansion, and capable of developing *2,000* indicated horse-power with a maximum speed of about *23 knots.* They are built by the firms of White, Yarrow,

Thornycroft and Lairds. Their armament consists of three 3-pounder quick-firing guns and three torpedo tubes.

The naval manœuvres of 1892, though they constituted a further development of the torpedo boat operations of the two previous years, cannot be said to have afforded many fresh lessons regarding the possibilities of that class of vessel. The boats were hampered, even more so than on previous occasions, by the shortness of the summer nights and the brightness of the moon. Had the nights been dark the damage inflicted by them, and the moral effect on the fleets, would undoubtedly have been greater. As it was they succeeded in delaying the junction of the two enemy's fleets for forty-eight hours, a feat of considerable importance. The performances of the "catchers" were even more valueless than in the year before and the authorities can hardly have seen in the result of the operations much encouragement for a continuance of their policy of building them. The French manœuvres of this year were chiefly remarkable for a very successful attack on a fleet at night by a flotilla of boats; on this occasion the Flagship was torpedoed before she was even aware of the presence of her puny assailant.

Since 1893 the British Admiralty have given but little attention to torpedo boat construction. Instead, they have concentrated their energies on the building of torpedo boat destroyers. The ten boats, however, which we have built lately are very fine ones, No. 92 having attained a speed of 24·5 knots. The dimensions of these boats are as follows: length 140 feet, beam 15·5 feet, draught 5·4 feet. Their total cost is £173,822. Other nations, notably France and Russia, have however continued laying down several torpedo boats each year. The French have in their seagoing torpedo boat *Forban* the fastest vessel in the whole world for 1895. She is built by the firm of Normand, of

nds & Co.

Fig. 46.—First Class Torpedo Boats Manœuvring.

Havre, and is fitted with two water-tube boilers of her maker's special design. Her engines are of 3,250 horse-power, an enormous energy to store up in a craft of 136 tons displacement, and it is not surprising, under the circumstances, that on her trials she attained the marvellous speed of 31·029 knots. The official trials were run in September, 1895. On the first, a run of 8 hours at 14 knots was made, when the fuel consumption per hour amounted to 423 lbs. The full speed trials which next took place were taken with the full sea-going load on board as well as the electric machinery, making a total of 16 tons. In an hour's run at full power a mean of the speed mentioned was attained, the coal burnt in this time amounting to 5,940 lbs. The machinery consists of two triple expansion engines. Her length is 144 feet 4 inches, beam 15·2 feet, and maximum draught 10 feet. The armament consists of two 37 mm. machine guns and two revolving tubes 13·78 inches in diameter. In spite of her great speed, however, it is exceedingly doubtful whether she would be a match for our fastest destroyers; indeed those of the latter laid down in 1895 with a contract-speed of 30 knots are more than likely to eclipse her in speed when their trials take place. At the same time it must not be forgotten that the smallness of size of the *Forban*, compared with our catchers, gives her an undoubted advantage over them when we consider her fitness for torpedo boat work. M. Normand is at present engaged in building a sister ship to her.

The French torpedo flotilla is divided into four different classes—namely "sea-going," "first class," "second class," and "third class" boats. The "sea-going" class includes all vessels over 135 feet in length and 14 feet in beam; their horse-power varies from 1,100 to 3,250 as in the case of the *Forban*, and their speed from 20 to 30 knots. Some of the "first class" boats attain a much higher speed

than the former, those built by Normand attaining on their trials as much as 24 knots; their length varies from 120 feet to 130 feet. The "second class" boats are mostly first class ones of old pattern, and many of them are hardly fit to leave harbour, much less go to sea for any length of time. A certain number of them however, notably those built at Havre and La Seyne, are capable of good work, and at the present time a batch of them, of improved type, are in course of construction. These latter are 120 feet in length, and expected to develop 20·5 knots. They are fitted with water-tube boilers. The "third class" boats correspond to a certain extent to the "second class" ones, and vary in length from about 60 feet to 90 feet. Their average speed is about 16 knots. All except about a dozen of them however are too heavy for carrying on the decks of battle-ships or cruisers, and in this important respect they differ from our second class boats. They are intended chiefly, if not entirely, for harbour work and coast protection, and are not intended to accompany a fleet at sea. The remaining boats are of lighter construction, and follow more nearly the second class boats in our Navy, which can be hoisted in and out of ships with ease, provided derricks or cranes of sufficient strength are carried.

It was not until 1893 that the French Government decided to follow our example in regard to torpedo boats of light displacement. They certainly possessed at that time half a dozen such little vessels, but they had been built many years before and were fast becoming worn out. But in the year in question the Ministry of Marine resolved that wherever possible small torpedo boats should form part of the equipment of their large cruisers and fortified depôt ships. Before launching into a regular scheme of construction in this direction, they wisely resolved to carry out a series of experiments with a view to discovering the best

material and form of engines and boilers for them. As a consequence they invited tenders from English and French builders for a sample vessel. The conditions laid down were a speed of 18¾ knots, adaptability for hoisting in and out of a ship, and a maximum displacement of 11 tons exclusive of load. A free hand was given in the matter of expense, and in consequence of this demand the first aluminium torpedo boat ever built was produced the following year, at Messrs. Yarrow's yard at Poplar.

As a result of numerous experiments it was ultimately decided that the little vessel should be built of aluminium plates half as thick again as what would have been adopted had ordinary steel been used; and as aluminium is one-third the weight of steel, it meant that the weight of the hull was reduced by one-half. Of course the plates were not of pure aluminium. That metal in its crude state is hardly of sufficient strength, and consequently experiments had to be carried out with a view to discovering the best alloy for boats' plates. "Ultimately," Mr. Yarrow tells us, "aluminium with 6 per cent. of copper was determined upon. The strength of this alloy may be considerably varied during rolling. If 'soft rolled,' *i.e.*, annealed after the last rolling, from 11 to 12 tons per square inch was obtained, with a large amount of elongation; if 'hard rolled' the strength was greatly increased, but the material was found to be brittle. Finally, the 6 per cent. alloy was adopted, rolled to a medium extent of hardness, giving from 14 to 16 tons per square inch tensile strength, combined with an amount of toughness enabling the plates to be hammered into shape cold, and to be bent to a sharp angle without showing signs of cracking. The framework of the hull consisted of angles of the same material. The plates and frames were all shaped cold, and no difficulty was found in carrying on the work in a

satisfactory manner; in fact there was not a single plate or angle to condemn."

Of course there is no denying that results such as these are distinctly favourable. Yet at the same time it must be remembered that all makers who have worked it have not been so favourably disposed towards the metal. For instance, in the aluminium boat on the Congo the rivetting plates buckled near the rivet holes. There is also considerable divergence of opinion regarding the merits of different alloys, some advocating an alloy of nickel, others of titanium. The latter metal, however, is precluded from serious consideration on account of its enormous price, though it appears to be undoubtedly the best of all. Aluminium is expensive enough, too, costing as it does about eight francs per kilo.

The boat which we are describing is built very much on the same lines as an ordinary second class boat in our own service. The engines are triple expansion, and the boilers of the water-tube pattern with copper tubes. Wherever possible, aluminium bronze and manganese bronze are introduced into the material of the machinery. Certain small working parts, subjected to little steam or friction, are of aluminium, as also the fans for producing the forced draught. The frames of the vessel are of steel, as also those parts of her which are subjected to any degree of heat from the boilers; for aluminium suffers a very large amount of contraction and expansion through variation of temperature. Curiously enough, however, an exception is made with the funnel casing which, though often subjected to intense heat, is made of aluminium, the expansion taking place through its length; or, in other words, the greater the speed of the boat the longer grows the funnel. That part of the deck in which it is stepped, however, is made of steel.

The trials of the little vessel took place in the autumn of 1894, and her appearance as she lay off the jetty waiting for her visitors may be fitly described as that of a bubble on the water. If, however, the lightness of the vessel was apparent to the eye, it was still more so when the order was given to go ahead. Though weighing but thirteen tons with three tons dead load on board of her, the speed rose to as much as 20·558 knots or $1\frac{3}{4}$ more than was contracted for, while the weight was one ton below the agreed maximum. In every respect the boat appeared a thorough success. Yet, alas! that great enemy of aluminium, corrosion, has already done much to shatter the hopes and expectations of her designers. Both she and the five others built after her have suffered enormously from this evil, and until a better alloy or an effective protective process is discovered it is hardly likely that aluminium will enter largely into torpedo boat building. The film of oxide which forms on the surface of the metal protects it to a certain extent, but in time the effects of weather and exposure slowly but surely eat it away. M. Moissan, the celebrated French chemist, has shown that sodium is sometimes present in aluminium in the proportion of 1-10 to 3 per cent. and even more. The presence of this impurity makes aluminium attackable by water, and is therefore an evil. When aluminium fails of homogeneity electric couples are formed in presence of water, which corrode the metal. On the other hand, M. Moissan has discovered that when aluminium is homogeneous, containing neither nitrogen, carbon, nor sodium, the water cannot attack the metal. This has an important bearing on the future construction of aluminium boats.

Within the last two years the United States have suddenly awakened to the necessity of arming themselves with torpedo boats, although up to this time they have shown an

extraordinary want of enterprise in this direction. By an Act of Congress, approved March, 1895, provision was made for the construction of three torpedo boats capable of steaming a maximum speed of 26 knots, and to cost individually $175,000, all parts being of domestic manufacture. The principal dimensions are length 170 feet, beam 17 feet, draught 5 feet 6 inches, and displacement 180 tons. The engines are triple expansion and twin-screw, and capable of developing 3,200 indicated horse-power, when making 395 revolutions per minute. The three boilers are water-tube, and are fired from the stokeholds in separate compartments. The speed, tonnage, and armament almost place them in the category of torpedo boat destroyers. As a matter of fact, so far as displacement goes, they come about half way between our destroyers and first class boats. Their armament consists of three torpedo-tubes, four 1-pounder quick-firing guns, four 18-inch Whitehead torpedoes, and 600 rounds of 1-pounder ammunition. Two of the tubes are placed forward in échelon, and the other is placed aft on the centre line; this arrangement gives a wide field of action. There are two conning towers, one forward and one aft, the former being surmounted by one of the quick-firing guns; the other three guns are placed in different positions about the deck, as in our own destroyers. The general shape of each vessel, too, is much like a small destroyer. There is the same turtle-back forward extending to the conning tower, and a flush deck extending from thence aft. These boats, if they fulfil the expectations of their builders, will be some of the finest torpedo boats afloat. Though their speed may not be as great as such boats as the *Forban* and *Corsaire*, their general design and displacement render them far more fit for practical work. Their behaviour on trial and in commission will be watched with the greatest interest by naval students.

FIG. 44.—A SECOND CLASS TORPEDO BOAT.

(Fitted with Dropping Gear.)

Russia is also taking pains to keep her supply of torpedo boats up to the proper mark. She has at the present time several boats building with a guaranteed speed of 25 knots. They are 138 feet long by 14·7 broad, and are fitted with water-tube boilers. Their displacement is about 118 tons. Altogether that Power possesses about 90 first class boats, and about 120 second class ones. Italy, too, possesses a fine flotilla, some of her boats attaining a speed of 25 knots. Japan is building in her own yards a large number of boats with a maximum speed of 20 knots.

It would take a volume larger than this to describe in detail all the torpedo flotillas of the different Powers. Suffice it to say, however, that every Power except ourselves which has any pretension to naval strength is devoting a considerable amount of attention to torpedo boat building. Our energies rather at present appear to be directed towards the construction of torpedo boat destroyers, which, as has been said, may be considered as large torpedo boats. These vessels are built for the declared purpose of ridding the seas of our enemy's torpedo craft, but as a matter of fact they will more often than not simply fulfil the duties of ordinary first class boats. At the same time it must be remembered that they are not by any means ideal torpedo boats. Their large size precludes them from being so, and a more moderate-sized boat with a speed of even 25 knots must be considered as more fit to deliver a torpedo attack, say, against a battleship or cruiser. The smaller the size the less the chance of being hit, and a reduction in speed of 2 knots will be more than compensated for by a loss in length of 50 feet. The high freeboard of the destroyers cannot fail, too, to render them much more easily distinguishable at night.

As has been already pointed out, life at sea in a first class torpedo boat has been vested by the press and public with

far more misery and discomfort than are found by actual experience. Of course, on the occasion of trips across the North Atlantic or through a heavy monsoon in the Indian Ocean, life on board a boat is about as unbearable as anything can be. But during the course of the manœuvres or in cruising along the coast, there are many things to compensate for the discomfort of being tossed about like a shuttlecock. In the first place the absence of strict routine such as is found in the ordinary man-of-war is a relief for both officers and men. The average seaman invariably hankers after a "piratical" life, and this is, in a way, what he leads in a torpedo boat. There is no bother there about the cut of the trousers or the length of the collar in the kit inspections; on the contrary, the regulation rig for both officers and men is an old serge or cloth suit, with sou-westers and oil skins, and sea boots; while at night or in cold weather, a "duffle" suit is worn. This latter garment is made of flannel as thick as a board, and comprises a pair of roomy trousers, and a double-breasted jacket, with a hood attached, for pulling over the head. A more cosy rig was never invented, and when it is worn underneath a thick suit of oilskins and sea boots the wearer can laugh at cold or rain alike; the only thing he has to be careful about is not to fall overboard, otherwise he will sink like a bag of shot. As has been said, the absence of routine is another attraction on board of a boat; or rather let it be remarked there are no regular hours or regular drills. A torpedo attack which cuts into the greater part of the night and which keeps every one on the *qui vive* for hours at a time, is calculated to upset the routine board of a torpedo boat, if such a thing existed. Officers and men have to sleep when they can, eat when they get a chance, and be ready for fighting at any moment throughout the twenty-four hours. On the other hand,

are kept religiously, and such important s as cleaning the steel "babies" or sounding the well, nd let it be added, serving out the grog—are never ected. There is one important feature of ordinary daily which is sadly neglected on board a boat, and that is ng. Fresh water is a precious article on board a which goes to sea, yet objects to salt water in her rs. There is nothing which the captain or his coxswain ds more jealously than the fresh water in the tanks d dinghy. The sea is considered liberal enough to pply the wherewithal for washing, and considerable esentment is shown should any one presume to be so andified or so careless of the interests of his shipmates as to steal the contents of his bath or basin from the ater-tank. The result is that at the end of a cruise ry one presents a very grimy appearance, though riously enough no one seems to mind it. There is reason for this parsimony too, for the efficiency of a torpedo boat depends very much indeed on her ability to keep the sea for a length of time without coaling or watering, and in the torpedo boat service, be it said at once, personal comfort is always sacrificed for the sake of the boat's good name. Indeed, it is hardly an exaggeration to say that the *esprit de corps* to be found on board a properly commissioned torpedo boat can hardly be surpassed anywhere.

The rations served out to the boats are, in the case of the men, much the same as on board an ordinary man-of-war. The grog, however, is not "watered," and this is just as well, for a man wants something substantial when he has been "bucketed" about by the sea all night and day. The officers mess themselves as best suits their tastes and pockets. Tinned meats and soups form the more solid part of the fare, while a ham is a good "stand-by" for rough weather as it can be easily slung from the deck above,

handy for any one to take a slice from it. In moderate weather, however, the little table in the after cabin is laid with a cloth, and the meal is served in a decent manner, the signalman doing the duty of steward, cook, and general bottle-washer. This individual may be reckoned, next to the commander, as the hardest worked man in the ship, and the duties of his position call for an exceptional amount of energy and good nature. One moment he is frizzling the bacon, the next answering or taking in a signal, or perhaps doing the officers' washing. The signalman of a torpedo boat, in fact, has to be what is commonly called a thorough "all-round man."

At night the officers sleep on the bunk-lockers on each side of the cabin table. The captain sleeps on one, and the sub-lieutenant and warrant-officer on the other, feet to feet. The chief engine-room artificer has a little cabin-hole just near the engine-room, and the remainder of the crew sleep on cork mattresses laid on the lower deck. When all are down below there is not too much room in a torpedo boat. The crew usually consists of a lieutenant, sub-lieutenant, and gunner, and about thirteen petty officers and men. The latter comprise one chief and one ordinary engine-room artificer; a coxswain, first-class petty officer; two other petty officers, one of whom is a torpedo instructor; one leading stoker; one signalman; three able seamen; and three first-class stokers. The chief engine-room artificer is the engineer of the ship, and a better class of man for the work could not be found. The reports of the captains of boats of their chief engine-room artificers have invariably been of the highest, for not only are they thoroughly conversant with the ordinary duties of the engine-room and stokehold, but they are excellent mechanics as well; the advantage of having them on board such a ticklish craft as torpedo boats is too obvious for

argument. The coxswain also holds a very responsible position. As has been explained in a former page, the rating of "torpedo boat coxswain" is a special one, for which certain high qualifications are necessary. His duties are somewhat analogous to those of the chief boatswain's mate in a large ship with those of the master-at-arms as well; whilst in going in and out of harbour or when delivering an attack, he takes the helm. The chief care of the torpedoes is given into the hands of the torpedo instructor.

Three watches are generally kept in the boats at sea, none in harbour. Each comprises one officer, one petty officer, and one able seaman. The two engine-room artificers and the leading stoker keep the three engine-room watches, assisted by the stokers in the stokehold. For some boats the crew is slightly larger than this, an extra greaser in the engine-room and another stoker being supplied. Both officers and men receive extra pay, or "hard line" money as it is called, when serving in a torpedo boat; and certainly they earn it.

The boat is nearly always steered from the wheel outside the forward conning-tower. Liquid compasses are generally used, the vibration and motion being too violent for the delicate instruments invented by Sir William Thompson. The deviation table of a torpedo boat is a peculiar one, the compass in the conning-tower often being six or seven points out. Still there is no trouble on this account so long as the boat is "swung" often, and the table kept correct. The Standard card compass is placed on the upper deck aft, just abaft the after conning-tower.

When delivering an attack the captain cons the boat from the forward conning tower, the coxswain steering. The forward pair of tubes are manned by the gunner, the petty officer and two men constituting the crew; the after pair are manned by the sub-lieutenant and his men; the

signalman stands near the captain; one of the petty officers stands by the searchlight. Down below, the chief engine-room artificer, assisted by a leading stoker and stoker, attends the engines; and the stokehold is in charge of the other engine room artificer and two stokers. Orders are transmitted to the engine room from the conning tower by the engine room telegraph, or else by the tubes or by word of mouth. When actually under fire every one would, as far as possible, be under cover, the tubes being trained on a certain bearing beforehand and fired by the captain from the conning tower. In the event of the boat's side being pierced by shot below the water line the hole would be plugged from the inside, and at the first opportunity would be closed with a "shot-pole stopper," consisting of a disc of rubber and metal washer pressed together by a screw spindle. In peace time the boat's hull and fittings are painted a uniform black, but in war time this would be changed either for a neutral tint, or grey and black patches. There is considerable divergence of opinion on this important point, and it is perhaps hardly likely that the question will be finally settled until actual warfare teaches us its solution. In any case, there is no tendency amongst naval officers to resent any attempt to render their boats more unsightly than they are under ordinary circumstances. It is fully recognised that "spit and polish" is out of place in a torpedo boat, and that, on the contrary, the vessel is meant for stern utility and not for any semblance of display, except in the sense of a menace.

The lot of a torpedo boat's crew in war time is undoubtedly a desperate one. Death by destruction or foundering, explosion of the boilers, collision, or premature explosion of their torpedoes are dangers which will have to be faced every moment in action. The constant strain will tell terribly on both officers and men, and if our boats are to be run

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efficiently it will be wise to relieve their crews every few days. There is little enough rest in a torpedo-boat, even during peace manœuvres. In war time there will be practically none. For ever on the *qui vive* for friends and foes alike, the crew's energy and vitality will be tried to an extent never before required from human beings. But whether the country's resources will allow for breathing time or not, the officers and men of our torpedo boat service will know how to acquit themselves when the time comes for the last great struggle. The old spirit which animated our sailors at Trafalgar will still be found in the men who hold the helm or drive the engines of a British torpedo boat. As a nautical poet puts it—

"Only a number, not even a name,
How shall posterity hear of my fame?
Perchance it may still live, after the grave,
In the name of an ironclad under the wave."

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FIG. 45.—H.M.S. "SEAGULL."

CHAPTER XII

TORPEDO CATCHERS

As in nature no living creature can be found which does not afford a prey to others, so in naval warfare there exists no type of vessel which has not some other specially designed for its destruction. The advent of torpedo boats into the Navy lists of the world was quickly followed by a class of ship peculiarly fitted to resist and attack these pests of the sea. In 1876, the very year that torpedo boat construction was first seriously entered upon, the German Admiralty designed the pioneer vessel of this class. The *Zieten*, such was her name, was built by the Thames Iron Works Company. Her displacement was 1,000 tons, and her dimensions 200 feet in length by 29 feet broad. Her engines were of 2,500 horse-power, and developed on a trial a maximum speed of 16 knots, or more than sufficient to overtake any torpedo boat of that day in the open sea. Submerged torpedo tubes were placed in the bow and stern, and the deck armament consisted of four 1½ centimetre guns and four machine guns. Both in steering and turning the vessel proved herself exceedingly handy.

The following year the Italians followed suit with a vessel of 550 tons, and the United States with two small armoured ones. In all three cases, however, the results

lingly discouraging. Three years after-
wards the Austrians constructed four vessels of about tons displacement, armed with torpedo tubes and hine guns, but none of them succeeded in attaining a r speed than 14 knots. In 1882–83 the Germans lt two more torpedo cruisers of 1,380 and 2,000 tons ectively, with a speed of about 16 knots; these, how- proved themselves too ungainly for the purpose for h they were intended. In 1885 both France and England, as a consequence of, what they considered, lessons drawn from the results of manœuvres, took up the building of this class of vessel seriously. Accordingly, France laid down the *Condor*, and England the *Scout*; both these craft were the pioneers of their class, and their dimensions were as follows:—

	Tonnage.	Length.	Beam.	Horse-power.	Speed.
Condor (French) ..	1,280	216 feet	29 feet	3,800	17·7
Scout (English)..	1,580	220 ,,	34 ,,	3,200	17

It will be seen that both types differ but slightly from one another. Their armament was also very similar, except that the *Condor* carried two more tubes than the *Scout*. Both vessels had excellent accommodation, considering their size; and their performances at sea, so far as their steaming capabilities were concerned, were as good as on their trials. But they both failed in two most important particulars, namely, handiness and manœuvring power. If they were to fulfil their duty properly, they ought to have been able to twist and turn about with as much ease and celerity as a torpedo boat; but they could not. They failed also on another point. Owing to their size and large freeboard, it was impossible for them to act the part of torpedo boats. It must be owned, however, that this was not one of the purposes for which their builders really designed them, though it can hardly be believed

that our Admiralty and the French did not really intend to apportion that duty to them in war time. However that may be, there is no denying the fact that, looked upon in the light of torpedo cruisers, the two classes were decided failures. They were quite unable to chase and destroy torpedo boats with any chance of success, and their build and manœuvring power precluded them from taking part in torpedo boat attacks.

Both the French and ourselves appear to have quickly come to a like conclusion, for at the end of the same year the former launched an entirely new type of vessel of smaller size and greater handiness, and the same thing was done by this country the summer following. In the French *Bombe* and the English *Rattlesnake* we find the pioneers of that class of vessel known now as "Torpedo Catcher." Their dimensions are as follows:—

	Tonnage.	Length.	Beam.	Horse-power.	Speed.
Bombe (French)	395	196 feet	21½ feet	1,800	18
Rattlesnake (English)	550	200 ,,	23 ,,	2,700	18·5

The armament of the *Bombe* consists of four 47 mm. quick-firing and three machine guns, and that of the *Rattlesnake* one 4 in. breech-loading and six 3-pounder quick-firing guns, while each vessel carries two tubes. It will be noticed that although the French boat is of considerably less tonnage than the English one, she is nearly as long, and her speed is also about the same. As might be expected, however, the *Bombe* class has proved too frail for sea work, except in the finest weather. Unlike the English destroyers of to-day, they have not the engine-power to drive them in a heavy sea, and, besides that, their lines and general construction cause them to make very bad weather on the slightest provocation. The *Rattlesnake* suffers, though to a less extent, from the same causes, but for all

that, although our Admiralty did not grasp the fact at the time, she is just as faulty in design and conception as her French contemporary.

According to certain scientific rules, if a vessel of the size of a large first-class torpedo boat is increased, her performances in the matter of speed become more and more unsatisfactory, even if the engine-power is considerably increased. This law holds good until such a displacement is reached as places the vessel in the category of cruiser or large gun-vessel. The torpedo catcher, however, has neither the displacement of a torpedo boat nor a cruiser; on the contrary, her size comes somewhat between the two, and she is consequently prevented from attaining the speed needed for her requirements. In entering upon the construction of torpedo craft of displacement varying between 525 to 810 tons, the Admiralty were practically striving after the impossible. Though boiler and engine-power were increased, the vessels went no faster, for the very good reason that their displacement was either too small or too great. There has probably never occurred in the whole history of mechanics such a triumph of theory over fact as this failure on the part of "Catchers" to fulfil the hopes of their designers.

The *Rattlesnake*, though the pioneer of this class of vessel, proved eventually to be about the best of the whole lot. Her designers, however, for the reason just explained, imagined that a slight reduction in displacement, with the same horse-power, would give better results. They therefore ordered three catchers, namely, the *Grasshopper*, *Sandfly*, and *Spider* to be built at once. These craft were launched the following year, and are of 525 tons displacement, but with more horse-power than the *Rattlesnake*, namely, 2,700. In all other respects they are practically the same. The boilers, four in number, are of the locomo-

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FIG. 46.—H.M.S. "RATTLESNAKE."

tive type with certain modifications, and are arranged in two stokeholds, each separate from one another, so that in the event of one of the boiler-rooms being disabled by shot, the two boilers in the other can still be available for work. The working pressure is about 140 pounds to the square inch. The machinery consists of two sets of vertical triple-expansion engines, having a stroke of inches, and capable of attaining their maximum horse-power at 310 revolutions per minute. The engines and propeller shafts are made of the finest Whitworth steel, and the propellers, which are three-bladed, are made of manganese bronze. This class of catcher carries about 80 tons of coal, which gives, at an economical speed of about 10 knots, a steaming capacity of 2,800 miles or enough to cross the Atlantic with. Yet although the vessels had certain undoubted advantages over torpedo boats in the matter of seaworthiness and radius of action, they were, on the other hand, sadly deficient in speed, and the Admiralty made no secret of their disappointment. Nineteen and a half knots was hardly the proper pace for a vessel which styled herself a "torpedo boat catcher."

The failure of the three 1887 boats to go any faster than the *Rattlesnake* had the immediate effect of rousing the Admiralty to a determination to solve the riddle before them as quickly as possible, and accordingly in the autumn of that year the keel was laid of the *Sharpshooter*, a Catcher of new type. A considerable amount of thought was expended in the preparation of her plans, or, as the First Lord himself said in his explanatory statement for the Estimates of 1888–89, they "engaged the close attention of the Director of Naval Construction and his department for more than a year, and involved a very large amount of labour and discussion." And no wonder!

The class of Catcher, of which the *Sharpshooter* was the first to be constructed, comprises twelve other vessels, namely, the *Gleaner, Gossamer, Salamander, Seagull, Sheldrake, Skipjack, Spanker* and *Speedwell* for the British Navy; the *Boomerang* and *Karakatta* for the Australian flotilla; and the *Assaye* and *Plassy* for the Indian Government. They are longer, heavier and more powerful than the *Rattlesnake* or *Grasshopper* class; but, be it said at once, in spite of all the hopes and trials of their designers, they are practically no faster. Although originally designed to steam 21 knots, hardly a single one of them can go more than 20 knots at a pinch and several of them only 17. A remarkable contrast, this, to the destroyers which, on their trials, exceeded their contract speed by one or two knots.

The *Sharpshooter* class were designed by Mr. W. H. White, the Director of Naval Construction, and are built, like their predecessors, entirely of the finest steel. They are of 735 tons displacement or about 200 tons more than the *Grasshopper* class, and are 230 feet in length, 27 feet in breadth, and with a maximum draught of 8 feet 6 ins. They are fitted with a long topgallant forecastle, but have no poop such as is found in the *Grasshopper* and her sister ships. The hull is divided into a large number of watertight compartments and a midship bulkhead runs fore and aft along the ship between the engine rooms. The boilers are of the locomotive type and the engines are triple expansion; when worked under forced draught they are supposed to be capable of developing 4,500 horse-power, and under natural draught 2,500.

This class of vessel is unarmoured, in the ordinary sense of the term, but its vital parts, namely the boilers and engines, are protected from machine gun fire by the coal bunkers which extend on each side and on top of the

boilers. The armament consists of two 4·7 inch quick-firing guns mounted forward and aft respectively, four three-pounder ditto, and three torpedo tubes; of the latter, one is fixed in the bow and the others are revolving ones placed aft. The vessel is controlled and steered from a large conning tower forward, on top of which is placed an electric search light, though in action in the daytime this would be removed. The coal capacity of 100 tons allows a run of 2,800 miles without either coaling or watering. This is not as much as the *Grasshopper* class can do, though those of the latter are 200 tons less displacement. Ever since they were launched the *Sharpshooter* class of torpedo catcher have given trouble. The boilers and machinery especially have caused a lot of anxiety to those in charge of them, leaky tubes and fractured machinery being quite a common occurrence. The hulls also appear to be structurally weak and unable to stand the strain and stress of rough weather, especially when steaming at full speed, in spite of the extra sea-worthiness gained by the adoption of a high topgallant forecastle.

The failure of the large batch of "catchers" built in 1889-90 to excel those of the *Rattlesnake* and *Grasshopper* class was again a bitter disappointment and puzzle for our naval constructors. The manœuvres of 1890 did not give much encouragement either. In that year four catchers took part in the operations, one of them, the *Speedwell*, being of the new class; but they made a poor show. The *Speedwell* was, on more than one occasion, within an ace of being captured by torpedo boats, and the *Rattlesnake* was actually taken prisoner by one of them.

Yet in spite of all these discouragements the Admiralty clung to their policy of building torpedo catchers with a persistence which was almost pathetic. No matter what theorists might say, it was inconceivable to them that a

vessel with five horse-power to every ton of displacement could not be made to go more than 20 knots, although they had no less than 17 vessels on their hands which were standing proofs of the unwisdom of their policy. So in 1890 orders were given for the construction of eleven more catchers of 810 tons displacement and 3,500 horse-power. In other words the new class were to be of the same dimensions and horse-power as the *Sharpshooter* type, but 75 tons heavier, so as to give them greater strength for cruising at sea. This was another attempt at solving the riddle, but it was doomed to as great a failure as those already made.

There was certainly little half-heartedness about the Admiralty's decision to build more catchers at the time in question. No less than eleven more were ordered in 1890, namely, the *Alarm*, *Antelope*, *Circe*, *Hebe*, *Jaseur*, *Jason*, *Leda*, *Niger*, *Onyx*, *Renard*, and *Speedy*. As has been explained, these vessels, which may be termed *Alarm* class, were of the same dimensions as the *Sharpshooter* type, though slightly heavier. All but one have locomotive boilers, which develop on an average 3,700 i.h.p., giving a speed of 19½ knots. This means that the new class of catchers actually attained less speed than those which they were supposed to be an improvement upon. The only exception was the *Speedy*, which is fitted with Thornycroft water-tube boilers, and which developed on her trials no less than 4,703 i.h.p., or more than 1,000 horse-power than the others of her class. Yet what was the result in speed? Only 20½ knots on the trial, and less ever since!

Surely no more convincing proof of the utter hopelessness of the problem which the authorities have striven to solve for six years could be instanced than this failure of a catcher, stronger by a full thousand horse-power than

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FIG. 48.—H.M.S. "SPEEDY."

her sister vessels, to beat them to any appreciable extent in speed. The startling lesson conveyed to the minds of the authorities came however a little late, for before the *Speedy* was ready for her trials the Admiralty, in a fit of desperation at their fourth failure to improve the speed of the vessels, plunged into another experiment, though fortunately for the pockets of the tax-payers on not such a large scale as formerly. In 1892 five more catchers of yet another type were ordered to be built, namely the *Dryad*, *Halcyon*, *Harrier*, *Hazard*, and *Hussar*. There were three reasons for the comparative smallness of the order. Firstly there was a tardy but growing suspicion arising in the minds of our constructors that their policy of the last six years, so far as it concerned the building of "catchers," was a huge mistake. Secondly, water-tube boilers were coming into fashion, and there was considerable curiosity regarding the relative merits and capabilites of the different types. And thirdly, a new class of vessel was springing into existence which promised to supersede the catchers entirely—namely, torpedo-boat destroyers.

The dimensions of these five new vessels are as follows: length 250 feet, beam 30½ feet, and displacement 1,070 tons. The horse-power however is the same as that of the *Alarm* class. This meant another step in construction—namely once more an advance in tonnage and size, but none in engine-power. The result was confusion worse confounded, for these superfine "catchers" actually acquitted themselves worse than any constructed before them! The *Dryad* was the first of this class to be finished, and her maximum speed amounted to 18·2 knots, or hardly sufficient to catch an old worn-out torpedo boat with. The results of the official trials of these five new ships were as follows:—

	Air Pressure in Stokeholds.	Horse-power.	Revolutions.	Speed.
Dryad	2·28	3709	242	18·2
Halcyon	2	3546	248	17·7
Harrier	1·77	3608	254	19
Hazard..	2·19	3734	260	19
Hussar.........	1·69	3553	253	19·7

The most curious feature about these trials is the distinct superiority of the *Hussar* over her sister vessels. Though the horse-power developed was almost less than any of them, her speed was by far the highest, and this would tend to prove that her lines were responsible for the difference.

The *Dryad*, whose machinery is shown in the accompanying diagram, developed both under natural and forced draught considerably more horse-power than the amount contracted for. Her engines are triple expansion, arranged in two sets, each fitted with inverted cylinders and driving a gun-metal screw propeller, with three adjustable blades. The four locomotive boilers are arranged, as will be seen on reference to the diagram, in two stokeholds, one at each end of the engine-room. The chief advantage of this arrangement is that in the event of one of the boilers being struck by shot or shell the two boilers in the other stokehold will be entirely free. The average working pressure is about 150 lbs. to the square inch.

In shape the *Dryad* type of torpedo catcher is like an enlarged *Rattlesnake*, that is to say, both a poop and top-gallant forecastle are fitted. The armament consists of two 4·7 in. quick-firing guns, mounted one each on the forecastle and poop, and four 6-pounder quick-firing guns. The latter are placed one in each forecastle sponson port, and the other two along the upper deck between the

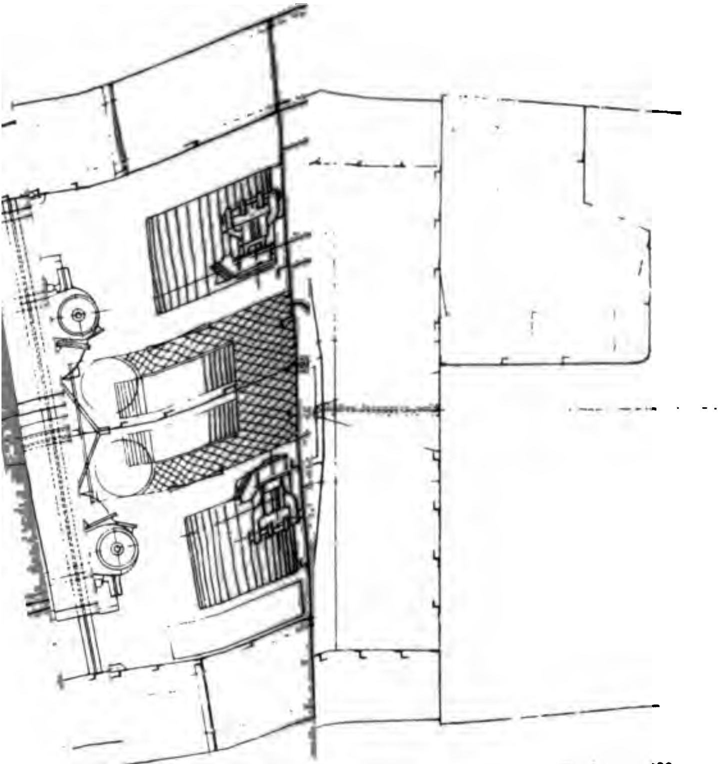
funnels. Five torpedo tubes for 18-inch Whiteheads are also carried. As might be expected from their size, these vessels are very roomy and comfortable down below, and of course altogether preferable in that respect to the destroyers. The crew of the *Dryad* numbers 115 officers and men.

The cost of the catchers has increased with the rise in their dimensions. The *Rattlesnake* and *Grasshopper* class cost altogether about £36,000 apiece, the *Sharpshooter* and *Alarm* classes from about £50,000 to £60,000, and the *Dryad* class about £75,000. It is practically impossible, however, to arrive at correct estimates of the comparative cost of the different classes owing to the alterations and continual tinkering that has gone on with them ever since their inception. While some have hardly been touched since they first left the dockyard hands, others have never been left alone. For instance, the *Sharpshooter* has had her old boilers pulled out of her, and Belleville boilers placed in instead. It was hoped that in spite of the small increase of speed obtained in the *Speedy*, which was the only one of her class fitted with water-tube boilers, that the Belleville boilers might give splendid results, but the hope was a vain one. The mean results for a three hours' run was 3,238 horse-power, but only nineteen knots. This, however, is an improvement on the speed derived from the old boilers, but not by any means sufficient to render the vessel efficient as a "catcher" in the proper sense of the term. Even supposing that the pressure in the stokeholds was increased, the increase could only be a slight one; that is to say if former trials are to be taken as a criterion. Another experiment is about to be tried with the *Seagull*, orders having been received by a firm of contractors to supply her with a set of Niclausse water-tube boilers, this type having been already fitted and

found to give satisfactory results in the French cruiser *Friant*.

There can be little doubt, however, that no matter what their type of boiler or design of machinery, the torpedo boat catchers of our navy can never steam at a greater pace than about twenty knots at the utmost. Even at a moderate speed they are constantly breaking down, and constituting an endless source of anxiety to their commanders and engineers. Not one of them has been able to sustain the speed obtained on the trials, and hardly a day passes when they are at sea without some part of the machinery or boilers developing serious defects. Indeed in even a moderate seaway their speed rarely rises above two thirds of their proper maximum, and the consequence is that they are quite unfit to accompany a modern fleet to sea for any length of time or any distance from a repairing base. Not only, too, are they deficient in boilers and machinery, but they are structurally weak as well. When the engines are running at full power they shake and tremble with a snake-like motion, and appear as if they must be literally shaken to pieces.

On the other hand it must be confessed that, provided the engines are driven at not too high a number of revolutions, the majority of the "catchers" are very fair seaboats. Several of them have passed through the ordeal of a gale in the Bay of Biscay with much less fuss than their larger consorts. But this good trait in their character only holds good so long as they are not called upon to fulfil the serious part of their duties. If, say, in a gale in the Irish Channel a catcher was called upon to chase and capture a first-class torpedo boat, there would be little chance of her doing so. Both vessels would be considerably handicapped i
heavy sea, but one would be as bad as the other, or,
rate, if the torpedo boat was one of the latest patter



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would be no chance whatever of the "catcher" overhauling her; whatever extra inconvenience the boat might suffer from the weather, over her larger rival, would be more than compensated for by the advantage in steaming power. Both France and Russia, and indeed nearly every maritime Power, possess boats with a maximum speed of twenty-three knots or over; the maximum speed of the fastest catcher is about twenty knots.

The question therefore naturally arises, of what use are the twenty-three so-called "catchers" which figure in our Navy List? The answer to this will be found in the fact that they are able to accompany a fleet at sea so long as it does not wander too far from a repairing base. In the event of a general action taking place in the Mediterranean or the Channel these vessels might be able to give a good account of themselves. They would not form up in the line of battle, but one or two might be attached, at a distance, to each group of cruisers or battleships, so as to be ready at the first fitting opportunity to rush in and deliver a torpedo. In the stress and confusion of battle there must be numerous opportunities for a vessel of the small size of a catcher to steal up comparatively unobserved, and deliver a blow from a quarter where it is least expected. They can also be used as scouts or despatch-vessels, on occasions when cruisers cannot be spared, or are not available, for that work. Every ship and every gun counts for something in a naval war, and though our catchers are looked upon as failures in a navy such as ours, they would perhaps be considered as valuable adjuncts to a naval force by any country but our own. As in every other class of ship, whether large or small, fast or slow, their sphere of usefulness can be widely extended if commanded by skilful captains, and manned by smart and resolute crews.

CHAPTER XIII

TORPEDO BOAT DESTROYERS

THE failure of the torpedo catchers to fulfil the expectations which had been held by their designers of their speed and general behaviour at sea led the Admiralty to decide on constructing an entirely new form of torpedo vessel. It was resolved that the new type should be larger than the first-class torpedo-boats, yet considerably smaller than the discarded catcher. The vessels, in fact were to be practically magnified torpedo boats of exceedingly high speed, which they would be capable of maintaining in a moderately heavy seaway, and armed in such a manner that they could either fulfil the duties of torpedo boat destroyers or ordinary sea-going torpedo boats. That the Admiralty were mathematically correct in deciding to build high speed vessels of a smaller size than the catcher is proved by Froude's formula. According to that rule, a vessel three or four times the displacement of the present destroyers presents far more difficulties in the way of attainment of high speeds than is found in the case of a vessel of the size of the latter. And by that rule, if the increase in dimensions goes on, a favourable size for extra high speeds will not be gained until the largest dimensions have been arrived at. Doubtless, too, considerations of expense

entered largely into the Admiralty's calculations, for the total cost of a destroyer amounts to only £36,500 compared with from £50,000 to £75,000 for a catcher.

But the paramount reason for the Admiralty's sudden decision to add a powerful torpedo flotilla to the strength of the navy was the strategical menace offered to us by the enormous number of torpedo boats which France was ranging along her Channel seaboard. It was clearly seen that should war ever break out between the two countries, our neighbour would be in a position to turn the English Channel into a veritable hornet's nest without our possessing any effective means to drive the plague away. It is true we possessed in 1892 a certain number of the so-called "catchers," though never in manœuvres or anywhere else had they ever succeeded in actually catching anything; and we had also a moderately-sized flotilla of first and second-class torpedo boats. But we could not hold a candle to the French so far as torpedo boats went, either in number, speed, or general efficiency. No wonder, therefore, that public opinion at last demanded that, at any cost, immediate precautions be taken against such a serious danger; and it must have been a profound disappointment to our neighbours, as it was a matter of intense satisfaction for ourselves, when the Admiralty suddenly announced that they had made up their minds to make up for lost time forthwith and to provide their country with a torpedo flotilla commensurate with its actual maritime strength.

The first order for destroyers was placed with the different contractors by the Admiralty in the beginning of 1893. By October of that year the *Havock*, the first of her kind, was launched from the yard of Messrs. Yarrow of Poplar, and her official trial took place on October 28th. The trials of this vessel, which will be subsequently described, were so exceedingly successful that the Admiralty

at once gave out the orders for the remaining boats, namely, two to Messrs. Yarrow, two to Messrs. Thornycroft, and two to Messrs Laird.

As their name implies, the torpedo boat destroyers of the British navy are built for the purpose of ridding the seas and the Channel in particular, of all torpedo craft which the enemy may dare to bring into action. Supposing, on the declaration of war with France, the English Channel was suddenly infested with about a hundred of the enemy's torpedo boats acting from several bases along their own coast. So long as those boats remained there the danger which would threaten our men-of-war and merchantmen would be so great as to render navigation in those parts at night almost impossible. Even in day time the danger would be so serious that it would be almost hopeless to persuade the underwriters to take risks, even at 90 per cent. premium.

It will doubtless be a hard task in war time, for our destroyers to clear the English Channel of these hostile torpedo boats, but if they acquit themselves anything like as well as they have done during their trials, their can be little doubt that success will eventually attend their efforts. Certainly during the manœuvres of 1895 there were several serious breakdowns amongst them, but without being unduly optimistic it may be reasonably surmised that those mishaps were due not so much to inherent defects in the boats themselves, as to the inexperience of the people running them. For it must be remembered that the destroyers, both in their engines, boilers and general construction, are entirely different to anything that the Navy, or indeed the whole world, has ever had experience of before. To cram an energy of 5,000 h.-p. into a tiny vessel of 250 tons, and to work the engines which develop that power at a frantic speed of 400 revolutions per minute, is to present a formidable duty to engineers, who up to the

advent of this class of ship have dealt only with ordinary ship's engines of moderate speed, or at least with engines whose horse-power was commensurate with the tonnage of the ship which they had to drive. A peep into the engine-room or stokehold of a destroyer when she is going at her topmost speed, is a sight which no man, be he the veriest novice or the most expert engineer, is ever likely to forget. The first feeling is one of wonder that the vessel herself can stand the awful strain and vibration of the forces acting within her; the second is astonishment that steam can be supplied fast enough, and that the engines can be properly attended when working at such a speed. And it is not only down below that the stress is felt. Those in charge of the navigation of the vessel have a duty to fulfil, which makes the strongest calls on their nerve and coolness. To go rushing through the water at such a speed that a broken neck is the almost inevitable fate of any one unfortunate enough to fall overboard, requires a steady hand on the helm, and a quick eye for observation. That this sudden advent of forty destroyers into the Navy has resulted, up to now, in so few mishaps, is a fact which our officers and men may well be proud of.

The first forty-two torpedo boat destroyers of the British Navy, so far as their general outward appearance is concerned, differ but slightly from one another. A few of the earlier-built ones are provided with a bow torpedo tube, which however was not placed in the later ones, owing to the discovery that the high speed of the vessel caused it to overrun the torpedo. The shape of the stern also alters in different boats in a manner which will be subsequently explained. Internally, however, the vessels differ from one another very considerably, and particularly so as regards their boilers. Indeed in the latter respect the destroyers may be divided into seven different types. Six of them

are fitted with locomotive boilers; ten with Yarrow boilers; eight with Thornycroft boilers; three with Blechynden boilers; four with White's boilers; eight with Normand boilers; two with Reed boilers; and one with Du Temple boilers. All these different boilers, with the exception, of course, of the locomotive, are simply various types of tubular. The engines of all the destroyers are to a great extent identical in arrangement and construction, the various makers each introducing some particular improvement or arrangement in the engines of the boats constructed by them.

Before, however, entering into a description of the engines and boilers of the different types, it will be as well to examine their general construction and internal arrangements.

The forty-two destroyers are all contract built, not a single part of them, hull or engines, being made by the dockyards. Fourteen different firms have participated in the work, the two well-known yards of Messrs. Yarrow at Poplar, and Messrs. Thornycroft at Chiswick having five boats each, and the other firms one, two or three. It is needless to make direct reference to each of the boats, for as has been already pointed out, they resemble each other in construction so closely, that any one of them may be taken as a very fair example of the others. For convenience sake, therefore, we will take the *Boxer*, built by Messrs. Thornycroft, as a model.

The torpedo boat destroyer *Boxer* was laid down in 1894 and launched in the spring of 1895. She is 200 ft. in length, 19 ft. in beam, and has a draught of 6 ft. forward and 7·8 ft. aft. Her hull is constructed entirely of the finest steel, about a quarter inch thick, so thin that on a day her frames can be clearly traced from the outsi the bulge which they make in the side, or rather, to ex

FIG. 50.—A TORPEDO BOAT DESTROYER.

more clearly, her side presents to a certain extent the appearance of a steel skin stretched tightly over an inner rigid frame work. Her displacement is 250 tons, or about the weight of the machinery of the *Halcyon* type of torpedo catcher.

The vessel is divided into seven separate compartments, in addition to those occupied by her engines and boilers. The water-tight bulkheads of these seven compartments have no doors fitted into them, access below being gained from the deck only. The foremost compartment of all is used for one of the seamen's messes. Right forward in the peak is what is called the "collision" bulkhead, into which a door is fitted, and inside this little peak compartment are kept the chain cables for the anchors. On each side of the fore compartment are fitted lockers and seats, with a mess table between them, and overhead, supported on rigid frames, is a little steam capstan. Underneath the floor is, on one side, the locker for the war heads of the torpedoes, and on the other side the magazines for the quick firing ammunition. This compartment is the loftiest of all in the vessel, being covered with a raised "turtle back" sloping down forward from the foremost conning tower, access to which is gained by a ladder against the after bulkhead of the compartment.

The next compartment is also used as a seamen's mess, and a very roomy and comfortable place it is, too, considering the size of the vessel. On each side there is a row of seat lockers, with a mess table, and fitted into the sides are receptacles for mess traps, ditty boxes, etc. Two large fresh water tanks are placed against the foremost bulkhead and large store cupboards against the after one. This mess deck is far more comfortable than the foremost one, as although the latter is more lofty it has the disadvantage of being subject to intense vibration when the vessel is

going at any high rate of speed. Indeed, the wonder is, on those occasions, that the steam capstan suspended overhead is not wrenched from its fastenings and deposited on the heads of the people below. However, the crew of a destroyer must be proof against such a petty annoyance as that. Taking them altogether, however, the seamen's messes on board a destroyer are far more comfortable than the size and general construction of the vessel would appear to warrant.

Next, abaft the seamen's messes are the boilers and stokeholds, and the engine room. All these will be explained afterwards. Again, abaft the engine room comes a small compartment containing the dynamo (which is placed against the forward bulkhead), the ship's galley, and two large fresh water tanks. This compartment cannot fail to be always an overbearingly hot one and in the tropics must be hardly fit to live in. The heat of the galley, in such a confined space, is bad enough, but when the dynamo is working the water in the fresh water tanks ought to be nigh boiling. The breadroom is underneath this compartment, so the biscuits will always be kept nice and dry, unless indeed a sea happens to get below.

The compartment next to the one just described is, however, a very comfortable one; in fact the most inhabitable of all, so far as its position in the vessel is concerned. It is allotted to the engine room artificers and the petty officers, who have their mess on each side of it, being divided from one another by a fore and aft partition. Locker seats on each side of a table, with cupboards, etc., comprise the furniture of each mess, and the height of the beams is such as to allow a full grown man to stand upright beneath them. The small arm magazine is underneath this compartment.

Abaft the petty officers' mess comes the wardroom. This

e expected, the most comfortable part of the ssel, not even excepting the captain's cabin. On de- ending the ladder leading down into the after end of this mpartment, one finds one's self in an outer cabin or pantry. the port side is a leaded space for "tubbing" in, with cistern and washing basin. On the other side are the tings of a little pantry, with wine and store cupboards. m racks and chart and chronometer boxes are also owed away in odd corners advantage of having a omfortable bath place down below and clear of the living cabin is a luxury which can only be fully appreciated by those who have experienced the dirt and discomfort of a torpedo boat. In the forward end of the little pantry compartment is the door leading into the wardroom. Here there are three comfortable berths, two on one side and one on the other, the remain g space on the port side being occupied by a lavatory, ich is entered from the pantry. Along the side of the berths are cushioned locker seats, with a large table between. Cupboards and a small library complete the furniture of this comparatively palatial abode. Indeed, so long as the elements outside are not so rough as to turn order into chaos, the wardroom cabin of a destroyer can compare favourably both in comfort and extent with plenty of yacht cabins which are looked upon by their owners as perfect little cribs. Though satin and rose wood and electro plated fittings do not find a place here, good solid mahogany and brass do just as well, and there is plenty of space to fill in with mirrors, photos of the fair sex, and other ornaments which the average naval officer likes to adorn his cabin with. Altogether there is little to complain of regarding the officers' accommodation on board these vessels, always of course, making allowance for their smallness of size. *Underneath* are stowed the electrical stores.

Next to the wardroom compartment comes that containing the captain's cabin. The chief drawback to the comfort of this place is its proximity to the propellers; otherwise, it is very comfortable indeed. On one side is a full-sized sleeping berth, and on the other a basin and chest of drawers. The size of a destroyer, however, precludes the captain from living apart from his officers in the complete manner adopted in larger vessels, and it is, perhaps, conducive to his comfort and happiness that such is so. He takes his meals in the wardroom, and it may be presumed that his cabin only sees him when he wants to sleep.

The aftermost compartment of all contains the steering engine and the engineers' stores. The steam steering gear of the destroyers varies very much indeed, each maker having his own designs and ideas on the subject. In the *Boxer*, which is constructed by Messrs. Thornycroft, there are two rudders, one on each side, actuated by one steering engine. The rudder spindles, which are of solid steel and of enormous strength, pass through stuffing boxes in the bottom, their weight being supported by brackets fixed in the deck. On each rudder spindle is a heavy toothed quadrant, with a cogged edge, and actuated by a worm fitted to a shaft leading from the steering engine. When the helm is amidships the rudders incline each towards one another $3\frac{1}{2}°$, and when hard over the steering arrangements throw all the strain on the spindles, and none of it on the engine. The valves of the latter are worked by a shaft supported on roller bearings, leading forward to another small shaft attached to the steering wheel. The screws revolve within a few inches of the inner sides of the rudders, which are curved round them. It might, perhaps, be thought that the inward inclination of the rudders acted as a check to the vessel's speed. Such, however, is not the

ients have clearly shown that the pressure on eir outer faces is greater than on the inner, with the conquent result that there is actually a small fore and aft essure which assists to propel the vessel.

The upper deck of the *Boxer* is perfectly flush from stern right as far as the forward conning tower, beyond ich extends the "turtle-back" over the fore peak. On h side of the conning tower, and extending across both des of the deck, is an ir ist-work, which prevents the water taken in over the bows from rushing aft, and shelters to a certain extent those standing on deck from spray and sea. On top of the armoured conning tower is a platform on which is mounted a 12-pounder quick-firing gun, and it is this weapon which will supply the means for carrying out the chief work of the destroyer, namely sinking torpedo boats. There are also two 6-pounder quick-firing guns on each side of the deck, and one right aft, making six quick-firing guns altogether. In addition to the guns there is a pair of revolving torpedo tubes mounted on deck, some distance aft, for discharging 18in. torpedoes. Four of the latter are carried in the vessel, two being kept stowed in the tubes and two under the turtle-back forward. In the first destroyers which were built, five torpedoes are carried, one of them being allocated to the tube fixed in the bows. In the *Boxer*, however this bow tube is not fitted. A large-search light is also fixed on the deck just abaft the funnels, the electricity for it being supplied from the dynamo in the galley compartment already described. In the *Boxer* there is only one funnel, but in several of the other destroyers there are more, the *Hornet* carrying as many as four. The remaining fittings on deck comprise the various ventilators for the engines and different compartments, hatchways, and chain deck rails extending all round the vessel. Two

boats are carried, one being an ordinary dinghy, the other a Berthon collapsible one.

Having now generally described the hull and fittings of a destroyer, we will proceed to examine the details of the engines, boilers, and propellors of the different types of that class of vessel built or building for our Navy.

As has been already mentioned, the first torpedo boat destroyer ever built and completed was the *Havock*, which was launched in October, 1893, by Messrs. Yarrow from their yard at Poplar. She is one of the five destroyers fitted with locomotive boilers, all the remainder being fitted with various forms of water-tube. The boilers are two in number and have copper fire-boxes with copper tubes. Lately, however, the authorities have substituted steel tubes instead. The total grate surface is about 100 square feet, and the total heating surface about 5,000 square feet. The vessel has twin screws and altogether in general form and outline greatly resembles an ordinary first-class torpedo boat of very large dimensions. The engines are of the usual tri-compound pattern adopted by Messrs. Yarrow, having cylinders 18 in., 26 in., and 39½ in. in diameter by 18 in. stroke. The total coal capacity is 60 tons, the supply being stowed in bunkers on each side of the boiler compartment. By this means the most vital part of the vessel is very fairly protected from the effect of machine-gun fire.

The first trial of this original destroyer was conducted under circumstances which might fairly be claimed as affording a very decided test of her seagoing qualities. It was carried out on the Maplin Course, right in the open sea, and with the wind blowing a fresh breeze, the vessel having been previously trimmed with no less than 35 tons of dead weight. The speed specified by the Admiralty was 26 knots, but this was largely exceeded

during a three hours' run under the conditions of weather referred to. Afterwards a series of runs was made on the measured mile, the resultant average speed working out to 26·783 knots. This was the fastest speed ever yet attained by any vessel in the whole world, and consequently caused a considerable amount of sensation amongst marine engineers and the public generally. It was also strongly suspected, and rightly too, that the constructors were not getting as much speed out of the vessel as they knew they were capable of doing. The bottom also was far from clean, and not polished up with black lead, as had been usually the case when torpedo boats were about to run their trials. But the most satisfactory point about the whole business was that this high speed had been attained by the agency of locomotive boilers. With water-tube boilers the results would not have been so surprising; in fact, the Admiralty stipulated for an extra knot in the boats fitted with that type. There was no difficulty whatever in keeping a good head of steam, only three inches water pressure being used in the stokeholds instead of the maximum of five inches. The coal figures were also equally satisfactory. In an eight hours' trial at economical speed of 11·2 knots, it was found that the consumption was less than a quarter of a ton an hour, and at 10 knots only 3½ cwt. per hour. This meant that the steaming radius of the vessel, without recoaling, was 3,500 knots, a remarkable radius of action for one of so small a size.

The second of the destroyers to be launched was also from the same yard, and her name the *Hornet*. She differs in one very important particular, however, from her sister vessel the *Havock*, inasmuch as she is fitted with water-tube boilers instead of locomotive, otherwise the construction of the two vessels is the same. This being the

first destroyer fitted with water-tube boilers the greatest interest was shown at her trial, though indeed a very fair insight had been gained into their capabilities on the occasion of a trial of one of them which took place in the Poplar yard a short time previously. Since this book does not presume to deal with the science of marine engineering, it will be sufficient if only a few of the leading results of this particular experiment are given here. The tube-heating surface of the tubes of the one boiler was 1,027 feet, and 20·6 feet of grate surface. In the presence of several engineering experts the boiler was filled to its proper height with perfectly cold water and the fire lit at 2.20 P.M. At 2.42 P.M. the steam gauge registered a pressure of 180 lbs. to the square inch! Two minutes before this the pressure stood at 100 lbs., but the blast being turned on, the pressure rose no less than 80 lbs. in two minutes. Soon after this, the fires were suddenly withdrawn, and yet no leakage or weeping of the tubes was discernible anywhere. No wonder that after such a performance as this the advocates of water-tube boilers in the Navy were pleased. The *Hornet* carries eight of these particular boilers, arranged in groups of four, with two stokeholds, each pair of boilers having one funnel, giving four funnels altogether. No such number has ever been carried in the Navy before, and even among the destroyers there are few which have so many.

At the *Hornet's* official trial on March 19, 1894, the mean speed for three hours with thirty tons' load on board, was 27·628 knots, the highest speed attained at that date. The horse power was 4,000, with steam at a pressure of 169 lbs. This very high speed was not kept up for long, after turning the vessel over to the dockyard authorities, owing chiefly to the fact that for some reason or other the Admiralty engineers insisted on altering the design and

arr[illegible]t of the pistons. This mistaken interference with the maker's original designs led to numerous mishaps, the piston rods at last actually breaking. As a consequence the Admiralty very wisely decided to abide by the former judgment of the designers instead of the advice of their engineer officers, who, however well qualified they might be to give valuable criticisms on the working and design of ordinary types of marine engines, had then had little experience of those [illegible] on board the destroyers. Orders were therefore given to the contractors to replace the broken Admiralty pattern piston rods with those of their own original design, and since then no breakdowns of a like nature have occurred on board the vessel. The propellers of both the *Hornet* and *Havock* are three-bladed and made of manganese bronze.

The trials of the *Havock* and *Hornet*, taken together, were chiefly remarkable for the marked superiority which they showed of water-tube over locomotive boilers. When giving out the contracts for the destroyers the Admiralty emphasised the fact that the high speed asked for could not possibly be reached unless every effort was made to supply them with boilers and engines which gave the maximum of power with the minimum of weight. That the use of water-tube boilers contributed largely towards the fulfilment of this ideal is evidenced by the disparity in weight between the boilers of the *Havock* and those of the *Hornet*. In the former vessel the locomotive boilers weigh altogether, when full, 54 tons; in the latter they weigh, when full, 43, or a saving of no less than 11 tons. In a vessel of only 220 tons displacement such a difference as this counts for a very great deal. If a comparison is also taken of the capabilities of evaporation it will be found that whereas 3,500 horse-power was indicated during the *Havock's* trial, in the *Hornet's* as much as 4,000 horse-power

was reached without any difficulty. The air pressure in the *Havock's* stokeholds also at full speed was 3 inches, whilst in the *Hornet* it was only 1½ inches. When these advantages, together with the short time taken in raising steam from cold water, are taken into consideration, the superiority of water-tube boilers over locomotive cannot be doubted for an instant.

The third torpedo boat destroyer to be launched was the *Daring*, from the yard of Messrs. Thornycroft. She is 185 feet in length, with a beam of 7 feet and an extreme draught of 7 feet. This vessel in common with all others built by Messrs. Thornycroft differs from other destroyers in two important particulars, namely, in the construction of her boilers and the build of her stern. In the Yarrow water-tube boilers the tubes are all *straight*. In the Thornycroft boilers the tubes are *bent*, with the object of preventing expansion strains. Which system is the best is a question which practical engineers and observation alone can decide. It would certainly seem that the straight tubes would be more likely to leak from the effect of expansion and contraction, the bent tubes having more freedom and elasticity. The Yarrow tubes, however, have the great advantage of being easily removed or renewed, and more important still can be kept under closer observation as to their condition. Should it be necessary, as it often is, for the tubes to be examined internally to discover what amount of corrosion is going on, the only manner in which this can be effected with the bent tubes is to select one here and there, cut it in half, and take its condition as an index to that of the rest. In the straight tubes this expensive and unsatisfactory mode of examination is obviated. It cannot be pretended that corrosion of the tubes is a rare event. On the contrary, it has been found already *that it is going* on in more than one of the de-

stroyers. A discussion as to the best means of preventing this evil, however, does not come within the scope of this work.

The peculiarity about the *Daring* and her sister ships is that the stern is flat underneath. Mr. Thornycroft, in his lecture before the Institute of Civil Engineers, said: "The shape of the stern at the water surface naturally suggests the fear that there would be slamming beneath it. Extended experience with this form has shown that there is no tendency to slam when under way. This is partly due to the action of the screws and partly to the fact that the great width of the stern at the water surface renders its vertical movements very limited. This tendency of the stern to follow the water surface makes it possible to place the screws higher than would be prudent if the stern were of the usual form, and the draught of water is very small in the *Daring*. It is less than that of most torpedo boats, and these cannot therefore escape pursuit by taking to shallow waters."

The engines of the *Daring* are of the three stage compound type, the cylinders being inclined from the vertical alternately to the right and left. The boilers are three in number, and placed in two stokeholds, the forward one having two boilers and the after one a single one. Another peculiarity about the boilers, in addition to that already mentioned, is that the water is fed to them by means of automatic floats, thus reducing the necessary personal attention to a minimum. On her trials the *Daring* attained the maximum mean speed of 28·232 knots.

The fourth destroyer to be launched was the *Decoy*, in August 1894. She was also constructed by Messrs. Thornycroft, and differs but slightly from her sister vessel the *Daring*. She, however, was not apparently so successful as the latter, attaining only a speed of 27·64. It is more

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FIG. 51.—H.M. TORPEDO BOAT DESTROYER "DARING."
(Fitted with Bow Tube.)

than likely, however, that her failure to show a higher speed was due to the very natural reluctance of her designers to strain her unnecessarily, their contract only specifying for a speed of 27 knots.

Of the forty-two destroyers included in the programme of 1893 all are now built. All of them have exceeded their contract speed and could probably, if occasion demanded, attain a speed of 29 knots, or perhaps more. Although differing but slightly from one another in outward appearance and general construction, their boilers are of many different types.

The *Contest*, *Dragon*, *Lynx*, *Banshee*, and *Ferret*, built by Messrs. Laird of Birkenhead, and the *Rocket*, *Shark*, and *Surly* by Messrs. Thomson of Clyde Bank, are fitted with Normand boilers. In this class of boiler none of the tubes are straight, particular care being taken thereby to guard against any leaking or straining through expansion and contraction. The gases from the furnaces are forced amongst the tubes and not straight into the funnel. The upper ends of the tubes in these boilers lead into the *lower* half of the steam chest. The tubes in the rows nearest the fire are of steel, and those forming the outside wall are of galvanized steel.

In all the destroyers fitted with these boilers the results have been very satisfactory. The figures in the first table on opposite page give the mean results for a three hours' run during the trials of the batch of boats built by Messrs. Laird and Messrs. Thomson.

Several of the vessels have been and are, in commission already, and a few took part in the manœuvres of 1895.

The Thornycroft boats *Ardent*, *Boxer*, *Bruiser*, *Decoy*, and *Daring* are fitted with boilers of their own maker's design, and the same have been put in the *Handy*, *Hart*, and *Hunter*, built by the Fairfield Shipbuilding Co. The

peculiarity of these boilers, in contradistinction to the Normand and other boilers, is that the upper ends of the water tubes lead into the *upper* part of the steam-chest, the

—	Mean revs. per Minute.	Steam Pressure.	Air Pressure in Stokeholds.	Maximum I H.P.	Speed.
Ferret	360	175	3 inches	4,500	27·508
Lynx	342	200	3 ,,	4,400	27·1
Banshee ...	350	200	3 ,,	4,400	27·57
Contest ...	350	200	3 ,,	4,500	27·357
Dragon ...	355	200	3 ,,	4,300	27·123
Rocket	396	188*	3 5 ,, *	4,200	27·4
Shark	401	184*	3 ,, *	4,250	27·6
Surly	403·8	187*	3·35 ,, *	4,175	28·05

* Mean for six miles' run at full speed.

water and steam from them being deflected downwards, on reaching the steam-chest, by baffle plates. The tubes are of steel, the outer ones being galvanized. There are three water chambers, two small and one large. The downcast tubes for the return circulation of the water, which are of large diameter and are arrayed in the middle line, run from the bottom half of the steam-chest down to the water chamber. The total weight of the three boilers with water and mountings is 48·5 tons. The following figures give some of the chief results of the trials of boats fitted with them.

—	Speed.		Steam Pressure.		Mean Air Pressure in Stokeholds.	
	6 miles.	3 hours.	6 miles.	3 hours	6 miles.	3 hours.
Daring ...	28·613	27·706	203·8	195.8	3·15 inches	3·25 inches
Decoy ...	27·641	27·763	198·3	194·6	3·25 ,,	3·5 ,,
Ardent ...	27·84	27·97	199·1	196·8	2·75 ,,	2·75 ,,
Boxer ...	29·08	29·17	209	207	2·62 ,,	2·96 ,,
Bruiser ...	28·144	27·97	206·3	208·7	2·33 ,,	2·9 ,,

The *Daring* during her preliminary trials attained a speed of 7·86 knots with 91 revolutions; 14·2 knots with 175 revolutions; 18·34 knots with 237 revolutions; and 28·65 knots with 387 revolutions. The economical speed of all the Thornycroft boats may be taken as roughly 11 knots, and the most uneconomical speed as 23 knots. At the latter speed the vibration is at its maximum, for curiously enough the faster the engines go above this rate the less becomes the disturbance.

Yarrow boilers have been supplied to the Poplar boat *Hornet*, the *Hardy* and *Haughty* from Messrs. Doxford and Sons, the *Opossum*, *Ranger*, and *Sunfish* from Messrs. Hawthorn, Leslie & Co., the *Salmon* and *Snapper* from Earles Shipbuilding Co., and the Elswick boats *Spitfire* and *Swordfish*. As has been already pointed out, a leading characteristic of this type is that straight tubes only are used. The Yarrow boiler also has another peculiarity which divides it from many of the other water-tube ones. It has no outside circulating tubes fitted. The principle adopted by other makers is that return tubes outside the fire are necessary for securing a good circulation in water-tube boilers. As to which of the two principles is the correct one, the writer does not presume to give an opinion, but in connection with this important question a most interesting correspondence has been going on in the columns of *Engineering* between all the leading authorities on the subject. Mr. Normand, the celebrated French torpedo boat builder, holds a different opinion to Mr. Yarrow in the matter. He says: "I prefer outside return tubes because they increase the activity of circulation, and allow of a greater intensity of firing, especially when the feed is introduced in the steam space, both conditions conducive, in my opinion, to an increase of the economic duty." On the other hand, Mr. Maxim, who takes the opposite side of the

question, points out that "when the fire is started in a Yarrow boiler the tubes next the fire are the first ones to be heated. An upward circulation is at once established in these tubes and becomes very rapid at the moment when steam first begins to show itself in the drum. It will be found that water charged with a large number of steam bubbles is ascending through the tubes nearest the fire, and that water of almost exactly the same temperature, but without steam bubbles, is descending through the outside tubes. As the fire is forced and more steam generated, the outside tubes also become steam generators, but the quantity of steam generated in them being vastly less than in those next the fire, a very rapid downward circulation is established which is so violent that it takes all the steam bubbles along with it. These enter the distributor at the bottom with the water and ascend again through the tubes in which the circulation is upwards. It may be presumed that about two-thirds or three-fourths of the tubes have an upward circulation, and the rest a downward circulation." In December 1895, Messrs. Yarrow, in the presence of experts, conducted a series of experiments bearing on this important and interesting question, and the result of them certainly went to prove in the most conclusive manner that the provision of outside return tubes is useless and unnecessary. Whatever too may be the value of the theoretical arguments brought to bear on the question, the practical success of this type of boiler is undoubted. Messrs. Doxford, who built them for the *Hardy* and *Haughty*, are loud in their praise of them, and the marvellous results attained during the trials of the Russian destroyer *Sokol* afford fresh confirmation of their practical efficiency.

The *Skate, Starfish* and *Sturgeon*, built by the Naval Construction and Armaments Co., use the Blechynden boiler. This is similar to the Yarrow boiler in so far that

it follows the principle of disputing with outside circulating tubes. The tubes, however, instead of being all straight are all curved, the inner ones being so more than the outer. The latter are placed in such a manner as to constitute a protection to the casing from the heat of the furnaces; they lead into the lower part of the steam-chest. The first experience with these boilers was an unfortunate one, a tube explosion, whereby an engineer and four men were killed, occurring on board the *Sturgeon* during her preliminary trial. As a result of her full speed trials, the *Starfish* attained 27·97, the *Sturgeon* 27·16, and the *Skate* 27·10 knots. All these three vessels are of the same length, namely, 190 feet.

Mr. White has placed boilers of his own particular design into the *Conflict*, *Teazer*, and *Wizard*, and the same is fitted into the *Zebra*, built by the Thames Ironworks Co. at Blackwall. The distinguishing feature of this type of boiler is the arrangement of the tubes, which are mainly formed into a series of double spirals, the lower ends being connected to the water-chambers, and the upper ends to the lower half of the steam-chest. There are also other tubes, nearly straight, which form a water wall, for the purpose of directing the flow of the furnace gases in their passage through the boiler. In this boiler outside circulating tubes are fitted. The spiral form of the tubes, though it may increase the heating surface and cause a more thorough commingling of the furnace gases amongst them, has on the other hand the undoubted disadvantage of rendering the cleaning and examination of the tubes a very difficult if not impossible business.

Reed boilers are supplied to the *Lightning* and *Porcupine* built by Palmer's Shipbuilding Co. The only point of interest about this type is that instead of the tubes being fixed into position by expansion with roller expanders,

their ends are fitted with a peculiar screw joint which allows a certain amount of play of the tube during expansion or contraction. External circulating tubes are fitted.

Du Temple boilers are fitted to the *Janus*, also built by Palmer's Shipbuilding Co. The tubes in this are placed zigzag, and are of narrower diameter at their lower ends. Outside circulating tubes are fitted. The *Janus* on her trials attained a maximum speed of 27·80 knots.

The foregoing description of the various types of water-tube boilers fitted to our torpedo boat destroyers embraces all the forty-two vessels included in the special programme with the exception of six fitted with locomotive boilers. These are the four Yarrow boats, *Charger*, *Dasher*, *Hasty* and *Havock*, and also the *Fervent* and *Zephyr*, built by Messrs. Hanna, Donald and Wilson. It would be unfair to compare the performances of these vessels with those fitted with water-tube boilers; indeed the contract speed for the former was one knot less than for the latter. The five boats in question are perhaps likely to attain as high a speed as many of the others, and it must be remembered that it was due to the remarkable success of the *Havock* that the Admiralty decided to build so many vessels of her type.

The auxiliary machinery which is fitted on board the destroyers is as ample as it is diversified. There are two powerful sets of air-compressing engines and pumps for supplying the air for the Whitehead torpedoes; a bilge pump for cleaning out the bilges of the stokeholds and engine-rooms; distilling apparatus capable of supplying 2,250 gallons of fresh water per day for boiler supply; a distilling condensor which can evaporate 450 gallons per day of pure aerated fresh water for drinking and cooking purposes; a large steam pump for general purposes; and a dynamo for the search light.

Communication between the engine-room and other parts of the ship is kept up by means of transmitters fitted inside and outside the conning tower and the after steering station. Ordinary mechanical telegraphs also connect the engine-room with the stokeholds and a complete system of voice-tubes is provided for keeping up communication between the different compartments throughout the ship. The rate at which the engines are working is shown to the officer on deck by revolution indicators specially designed for high-speed engines.

The stokeholds of a destroyer are fairly roomy considering the size of the vessel. It is lucky that such is so, for work in them at full speed is very heavy indeed, and a cramped space would detract very much from the quality of the stoking. When going at a moderate speed only about half the boilers are in use, but at full speed all the furnaces are at forced draught and the firing goes on without intermission. A whirlwind of dust-laden air driven in by the steam fans, rushes through the stokeholds into the furnaces. The light from the fires is bright enough in an ordinary ship's furnace, but in a destroyer it is of such dazzling whiteness that coloured glasses are necessary when the doors are opened and the fires are being trimmed. In a heavy seaway when the vessel is rolling and pitching as if she was bewitched, life in a destroyer's stokehold under forced draught is an experience to be avoided as much as possible. To watch the water and steam gauges carefully and to keep a good head of steam under such circumstances requires cool heads and strong arms; happily our stokers have both. The bunkers are arranged in such a way as to give the greatest amount of protection to the vital parts of the vessel, but there are many officers who hold that this protection is not enough.

The thickness of the steel used in destroyers, both

British and foreign, varies according to the position, from a quarter of an inch to a little under half an inch. The thickness of the conning tower also varies according to the wishes of the different governments. Some attach considerable importance to its being armourplated, while some do not insist upon the point at all. In the British boats the conning towers are plated at the sides with ½-inch steel, but even with this thickness, be it remembered, they are only partially protected from the effects of machine-gun fire. The ½-inch plating, too, does not extend all round.

In the chapter dealing with torpedo boats it has been pointed out how extremely successful has been the armoured torpedo boat built in England for the Japanese Government. The question now naturally arises, what would be the effect on torpedo boat destroyers if they were similarly armoured. Of course the answer to this question would depend entirely on the thickness of the armour used. In the Argentine torpedo boat destroyers, four of which are being built in England, the sides of the machinery space above the water line and a little below it are ½-inch thick. This would afford protection from the hottest rifle fire, but not from the steel bullets of machine guns. Now the loss of space due to this armour is partly in consequence of the increased weight, and partly to the increased beam which its presence renders necessary in order to insure stability. Mr. Yarrow, when questioned by the author on this point, estimated the reduction of speed due to this amount of armour at one and a half knots, and if the plating be one inch at the sides probably the reduction of speed would be two and a half knots more, that is to say, a total reduction of four knots. This means that the British destroyers, if armoured in their vital parts with one inch armour, would have a maximum speed of about

twenty-five knots. That of course is a very serious reduction of speed and very powerful reasons must be given to prove that such a load of armour is wise or necessary. In judging this important question the first thing to consider is what are the duties which torpedo boat destroyers are likely to have allotted them in war time. Firstly they would have to clear the Channel and Mediterranean of all the enemy's torpedo boats. If we take Russia and France as the Powers fighting us, we find that the former possesses four boats with a maximum speed of twenty-five knots, one destroyer with a speed of twenty-nine knots, and more of the latter type building; France possesses a dozen seagoing torpedo boats of that speed and eighteen first-class boats of twenty-four knots and over. Clearly therefore our destroyers must be capable of steaming at least twenty-five knots if they are to fulfil the chief purposes for which they are built. On the other hand it must be remembered that their extra seaworthiness and ability to steam into shallow waters gives them an advantage over vessels of smaller size, speed for speed. If again we consider the destroyers in the light of seagoing torpedo boats, twenty-five knots is unquestionably ample for them. It would therefore certainly seem that armoured destroyers capable of steaming at that rate cannot fail to constitute a most valuable type of vessel, and they would at the same time possess many meritorious advantages which do not belong to destroyers constructed on present lines.

According to figures given by Mr. Thornycroft in his lecture at the Royal United Service Institution the destroyers must necessarily be quick rollers on account of their small size, and their metra-centric height which, with all weights on board and twenty tons of coal in the bunkers, is 2·48 feet. The righting moment is a maximum at 46° and vanishes at 95°. Owing probably to the greater

heeling effect of small movements of the helm at full speed, the stability is then actually reduced as compared with the normal still-water condition. At full speed the destroyers produce a considerable amount of spray and wash forward, even in smooth water, and this is especially so when loaded with the full amount of coal and water. As has been already pointed out, a steel breastwork extends across the upper deck on each side of the conning tower to a height of about three feet. This however, though sufficient to keep back the solid part of the water which is taken in over the bows, is no protection against the spray which dashes up the sides. To obviate this uncomfortable state of things a sort of canvas screen has been devised which juts out all round the edge of the forecastle at right angles to the ship's side and in line with the deck, to a distance of about eighteen inches. The screen is stretched on hinged rods which can be turned back when not in use. In perfectly smooth weather this arrangement might be of some utility, but at the time when most urgently required, namely in a seaway, it would be quite ineffectual, for withstanding the shock of any moderate-sized body of water.

Although both in general design and placing of the engines every effort has been made to reduce the vibration in destroyers to a minimum, there is no doubt whatever that a very great deal still remains to be done in this direction. The vibration at twenty-five knots is worse than at full speed, but it is bad in both cases. When the two engines are, as it were, working in unison the vibration is comparatively easy, but directly they get out of step with one another it is very violent indeed. Not only does this cause the greatest discomfort amongst the crew, and especially those living right forward, but, what is perhaps more serious still, it detracts enormously from the steadiness of the firing. The largest gun in the ship, the 12-pounder

quick-firer, is mounted right on top of the conning tower, and occupies about the worst position possible, so far as vibration is concerned. Some of the builders have tried to demonstrate that the vibration is so small that it can have no practical effect on the gun-fire, but any one who has stood on top of the conning tower and looked along the gun sights when the vessel is going about twenty-five knots will scout the contention. The vibration is very violent indeed, and this, taken in conjunction with the rolling and pitching motions of the vessel, reduces the efficiency of a destroyer in a seaway very considerably. A special form of steady gun platform has been invented with a view to obviating this difficulty to a certain extent, but whether it is really of practical use or not remains to be seen.

The rolling motion might also be considerably reduced by the adoption of bilge keels. No one, however, has yet brought forward any invention which will keep a gun platform steady in a ship which is being shaken almost to pieces by her engines.

Another great defect in destroyers—and also torpedo boats—as at present constructed, is their tendency to flaming from the funnels when running at a very high rate of speed. In an attack at night a torpedo-vessel which is proclaiming her presence with a flaring beacon is worse than useless, for not only does she attract the attention of the enemy to herself, but most probably to the vessels acting in concert with her as well. How often too have commanders of torpedo-boats been nearly driven mad with exasperation on account of a tell-tale flame suddenly announcing their boat's presence to the enemy, just as a hitherto carefully concealed attack was about to be successfully delivered. This "flaming" is an old-standing fault in torpedo vessels of all classes, and it is surprising that so

little effort has been made towards its removal. Of course the evil is due chiefly to faulty stoking; but it must be remembered that stokers after all are only mortal, and it is not surprising if they flag in their energy at odd moments. But, unfortunately, it requires but a few seconds neglect of the fires to produce a flame from the funnel. Mr. Thornycroft, on one occasion when questioned on this point, explained that the cause of the flame is owing to so much coal being put into the furnace that the gas from it is distilled in there and burnt in the top of the funnel. The other cause is that when the boats are taxed to their very utmost the capacity of the boilers is not sufficient to absorb all the heat, and some of the latter must necessarily come out. He believes too that the evil may be partly overcome by adding more air in the furnace and by better mixing of the gases. Apparently, however, this entails a slight reduction in the maximum speed, a highly unsatisfactory method of meeting the difficulty.

It will have been noted the highest speed obtained from any British destroyer up to the present time (December, 1895) is 29·17 knots from the *Boxer*, in a three hours' full speed trial. She, however, is eclipsed by the *Sokol*, a destroyer built for the Russian Government by the Poplar firm. This vessel was launched on August 22nd, 1895, and is 190 feet long by 18 feet 6 inches beam, and is the first destroyer in which nickel steel has been adopted as the material of construction, a class of steel which has a strength exceeding that of the ordinary metal by about 30 per cent. Her armament is almost identical with that chosen for our own vessels, and consists of two revolving Whitehead torpedo tubes, one 12-pounder mounted on the conning tower forward, and three 6-pounders mounted along the upper deck. The coal carrying capacity is about

sixty tons, or sufficient to steam across the Atlantic with at least a speed of 10 knots.

The engines of the *Sokol* are twin screw triple expansion and capable of developing over 4,000 i.h.p. Their position and general arrangement can be seen on reference to the accompanying diagram. Bronze enters largely into their construction. Steam is supplied by eight Yarrow water tube boilers of the type already described, and arranged with a forward and after stokehold. A particular feature regarding them is their enclosure in special compartments by cross bulk-heads, thus isolating them from the engine-room should they be pierced by the enemy's shot. The importance of such an element of security cannot be over-estimated. When the vessel was launched all the machinery, main and auxiliary, and boilers were on board, and fires alight and steam up in four of the boilers. The following day the first preliminary trials took place and proved a marvellous success. The following were the actual results taken on the measured mile off the Maplins :—

Steam Pressure.	1st Receiver.	2nd Receiver.	Vacuum.	Air Pressure in Stokehold.	Revolutions per Minute.	Time.		Speed.	Mean Speed in Knots per Hour.
						min.	sec.		
124	48	4	24½	$\frac{7}{16}$	334	2	39	22·641	25·778
130	54	7	24½	$\frac{9}{16}$	355	2	4½	28·915	
136	54	8	24	$\frac{7}{8}$	364	2	22	25·352	27·802
145	60	8¼	24	$\frac{3}{4}$	386	1	59	30·252	
154	64	10	23	$1\frac{5}{16}$	412½	2	10	27·692	29·363
162	67	10½	23	$\frac{7}{8}$	402	1	56	31·034	
164	71	11	22	1	412	2	6	28·571	30·285
165	72	11	22	$1\frac{1}{8}$	426	1	52½	32·000	

The most remarkable feature of this truly remarkable trial was the lowness of the steam pressure, and air pres-

sure in the stokeholds, in comparison to the high speed attained. That a velocity of over 30¼ knots per hour should be possible with only a steam pressure of 165 lb. is certainly very clear evidence of the wonderful possibilities of water-tube boilers. Before this book has been many months in print, the *Sokol* will have been beaten by her English contemporaries in the matter of speed; but the vessel will still, owing to her perfection of construction, constitute a very formidable addition to the strength of the Russian Navy, and afford a good example of what a torpedo boat destroyer should be.

At the time this is written 28 more torpedo boat destroyers, with a contract speed of 30 knots, are being constructed by five different firms, and orders for twenty more will shortly be given out. The first batch include the *Desperate*, *Foam*, *Fame*, and *Mallard*, having a displacement of 272 tons, of 5,400 i.h.p., and thirty knots speed; and the *Quail*, *Sparrowhawk*, *Thrasher*, *Virago*, *Brazon*, *Electra*, *Recruit*, and *Vulture* of 300 tons, 6,000 i.h.p. and thirty knots speed. When these 48 extra boats are delivered we shall have a flotilla of destroyers 90 strong. As far as speed and efficiency goes this is the strongest torpedo fleet the world has ever yet seen, and when we include the catchers and torpedo boats we shall have at hand a force which is capable of striking a crushing blow to any combination of torpedo flotillas which is likely to attack us. In the destroyer we have really only a large seagoing torpedo boat. It is true that by increasing the size of the boat we add to its chances of destruction in action. Yet the increase is not an unreasonable one, as in the case of the "catchers," and at any rate what is lost through increase in size is more than compensated for by greater seaworthiness, larger radius of action, and increased

speed. Another great advantage which the British destroyer possesses is its light draught, and consequent ability to follow torpedo boats into shallow harbours or roadsteads. The French seagoing torpedo boats have a draught of about 8 feet, in comparison to an average of about 5·2 feet for the British destroyers, and that in spite of the fact that the former are considerably smaller than the latter. The *Forban* the fastest vessel at present in the world, draws as much as 10 feet, and she would consequently be almost at the mercy of a British destroyer if running in shallow waters. All the French first-class torpedo boats draw over 7 feet of water, and the Russian ones about the same. The only thing that can handicap the destroyer in harbours or confined channels, is her enormous engine-power compared to her actual displacement. So great is the energy contained within her that but a few revolutions of the engines are sufficient for her to gather as much way on as an ordinary vessel would develop in a few minutes. Let the stop valve be opened ever so little and the vessel starts forward like a whipped horse, and runs imminent risk of running ashore or coming into collision with her neighbours. There is only one way of getting over such a fault as this, and that is to train officers and men to know how to handle such ticklish vessels. A man who can ride a park hack cannot necessarily ride a steeplechaser; no more can a man, because he is a seaman in the ordinary sense of the term, be expected to handle a destroyer efficiently, unless he is qualified beforehand by special use and training to do so. And what applies to the officer of the watch in a destroyer, applies with equal force to the engineers and seamen. Practice alone can give a man the necessary nerve to drive marine engines at 450 revolutions per minute, and the

wonderful steadiness and quickness of aim that is required in the captain of a gun which jumps about as if it had St. Vitus's dance. Croakers may tell us that in the British Navy seamanship is a lost art, but let them remember that there is more to learn in the handling of a destroyer than was ever required in watching the leech of a main topsail.

CHAPTER XIV

SUBMARINE BOATS

The problem of submarine navigation has always been a fascinating one for scientists and seamen, and many are the lives that have been lost and the money expended in the search for its solution. The *Nautilus*, that wonderful creation of the fertile brain of Jules Verne, will perhaps one day appear as a poor prophecy of what will then be a reality; but if the present outlook is to be trusted it will be a long time before the world sees such a marvellous piece of construction as that commanded by Captain Nemo. Still he must be a bold man who will say that submarine navigation is not within the range of human possibilities. We are as yet only touching the fringe of that great and all-pervading force electricity, and when the day comes that we are able to utilise it in the manner suggested by the novelist the problem of subaqueous locomotion will be solved.

It would take up far too much space if we were to try and recapitulate all the attempts made in the past to build a submarine vessel. Suffice to say that such a history would be little more than a catalogue of machines which have been more often than not the invention of crack-brained enthusiasts. Some of them were, on account of

their utter impracticability and weakness of design, doomed to failure from the moment of their conception; others displayed ingenuity worthy of a better and more remunerative cause. Once, and once only, has a submarine vessel been put to the test of actual warfare, and that was during the course of the American war when one of the antiquated northern ships, was blown up by a craft of this description, after five attempts. The pity of it all however was that the explosion destroyed both parties. Most of the other experiments in this direction came to a conclusion through explosion, failure of air and consequent suffocation of the crew, or an unfortunate tendency of the vessel to stick in the mud and remain embedded there.

During the last three or four years however it must be admitted that some real advances have been made in the art of building submarine vessels. In October 1894, Mr. Seymour Allan, of Sydney, produced a submarine torpedo boat, or rather a working model of one, which certainly showed a great improvement over its predecessors, and the Naval Commander-in-Chief on the Australian Station, who witnessed the model running, diving, and turning in the public baths of Sydney, declared that "if the vessel would do what the model performed, naval warfare would be revolutionised." The British Admiralty, however, are not given to encouraging experiments of such a novel and risky nature, and up to the present Mr. Allan's invention has not received that attention from the authorities which its model's performances would appear to have called for; or perhaps the vessel herself was not so satisfactory as her designer had hoped she would be.

Probably the most influential exponent of submarine torpedo boats who has yet come forward, is Admiral Aube, of the French Navy. This officer, when Minister of Marine, made a *special* hobby of this mode of naval war-

fare, and although he never succeeded in finding anything which really came up to his requirements, one at least of the numerous inventors whom he protégéd has succeeded in producing a very fair specimen of submarine torpedo boat, though for a foreign government. In 1888 M. Goubet, such is the inventor's name, submitted a submarine boat driven by electricity derived from accumulators. The vessel, which at the best was only able to go five knots, was not a success; but Admiral Aube gave the inventor further encouragement, with the result that the Brazilian Government have another one built by him, but in a decidedly improved form. In the meantime however the French Government have become possessed of three other submarine torpedo boats besides the old Goubet vessel. Their names are the *Gymnote* built in 1888, the *Gustave Zedé* in 1893, and the *Morse* in 1895. The *Gustave Zedé* is quite the largest submarine vessel yet built, being 130 feet in length with a displacement of 265 tons. Her motive power, electricity, is derived from accumulators, but the poisonous fumes emanating from them have on several occasions all but overpowered the crew. On more than one occasion also these accumulators have exploded for some mysterious reason, with the result that the boat has been severely damaged, and large sums of money expended on her repair and alterations. The boat has been submerged to as great a depth as 65 feet whilst proceeding eight knots through the water, and she and her crew have actually remained below the surface for several hours at a time, discharging torpedoes. The *Morse* is built on very similar lines, but to all appearances she promises to be as little successful as her sister vessel.

The new *Goubet* built for the Brazilian Government is, however, decidedly superior to her predecessors. She does not aspire to cruise about beneath the waves like a torpedo-

boat on the surface, but, on the contrary, is only meant to pierce the water at a moderate speed of seven or eight knots per hour. She, in fact, trusts to her invisibility and consequent invulnerability to more than compensate for her slowness in speed. Her attacks will be carried out by stealth and not by rushes. The new *Goubet* is much smaller than her prototype, being 26 feet in length, 5 feet 6 inches in diameter in the middle, and with a displacement of 10 tons. She is spindle-shaped, and cast in three sections bolted together, the material of her hull being gun-metal. A little manhole-dome surmounts the middle section, and projects about a foot above the top. On each side of her is a lateral horizontal keel as a guide to stability, and each keel carries a Whitehead torpedo. The boat is propelled by an electric motor, the electricity for which is derived, not from accumulators, as in the case of other submarine boats, but from Schauschieff batteries capable of developing one and a half horse-power in the motor. This is sufficient for pumping purposes as well. The screw is mounted in such a way that it can be turned about like a rudder, and therefore dispenses with the necessity for the latter; and so effective is it in its action that the vessel can turn almost in her own length. In addition to her electrical engines, the *Goubet* has a "stand by" in the shape of a pair of oar-like fins which can be manned by hand, and which propel her along at about two knōts. These "oars" would be used when the boat had approached close to the object aimed at. The engines would then be stopped, the "oars" manned, and the boat placed in such a position that her torpedo would point direct for the enemy, and fired.

When launched into the water the *Goubet* floats with the manhole just emerging above the surface. On proceeding to descend water ballast is pumped into the boat, a gauge in the dome marking the exact depth to which the boat is

steady; and so long as the gauge-cock is let alone, the boat remains at exactly the adjusted depth, an ingenious arrangement instantly checking any tendency to rise or sink below it. On wishing to rise to the surface the electric pump is made to expel the water ballast from the boat. The batteries can be charged for fifty-two hours active work, driving and pumping, and enough air can be compressed into the reservoirs to last the crew for a week or more. The air is kept at a normal condition and pressure by steel tubes containing oxygen and ozone, whilst the vitiated gases are expelled by a special form of pump. On ordinary occasions enough air would be carried to last about fifteen hours. As an element of safety a heavy weight, equal to the extra ballast in the boat, is suspended beneath her, and this can be released by a spring at will, with the result that she rises at once to the surface like a cork. Another important feature about the *Goubet* is that she never inclines from the horizontal, simply rising or sinking at the captain's will without any tendency whatever to dive downwards or upwards.

Of course the difficulty experienced by divers in seeing objects for any distance below the surface, applies with equal force in the case of a submarine boat; but Mr. Goubet tries to get over this drawback to a certain extent by first bringing his boat to a depth of a few feet. He then uses an optical tube, which, by means of a pneumatic telescopic apparatus, can be protruded above the surface, and pulled down in a moment. This telescope has a system of prisms and lenses which causes the image of the sea surface to be deflected down to the eye of the observer below, the object-glass above being no bigger than a crown piece. With this simple apparatus the surface can be quickly scanned—in fine weather.

If the *Goubet* acquits herself in the hands of the Bra-

zilians in the same manner as she did on the Seine, there can be no doubt that she will constitute a valuable and certainly exceedingly interesting addition to her owners' navy. To blockade a harbour containing such a treacherous craft would undoubtedly be a risky business, for it would be within her power to creep up completely unobserved and place a torpedo into her enemy without running any risk to herself. The little optical lens could of course be no target for the enemy, and if the speed of the vessel was kept as low as possible there would be no tell-tale eddy or wake to indicate her path of approach. The future performances of this curious little vessel will be well worth watching.

The United States Government is now about to launch a torpedo boat which can either be driven on the surface by steam like an ordinary boat, or else beneath the surface by motors fed from accumulators. Her shape is like a double pointed cigar, and her full speed is expected to be sixteen knots. Her dimensions are: length 80 feet, beam 10·5 feet, tonnage 150, and horse-power 1,000. Altogether the vessel is a "big order," and it will be as well to await the actual result of her trials before discussing her merits and capabilities. Italy, Portugal, Turkey, and Sweden have also made attempts at solving the problem of submarine navigation, but so far there has been no sign of real success in that direction. Nor is there likely to be for some time to come, or at least until our electricians are more versed in the science of electrical storage.

CHAPTER XV

THE TORPEDO AND ITS PERFORMANCES DURING THE LATE WAR

So many accounts have been written of the performances of torpedoes and torpedo boats in war time, that a chronological account of them in this volume can only weary the reader. It will be sufficient therefore to confine ourselves to an intelligent examination of the actual damage inflicted by them during the Chino-Japanese war when modern torpedoes, modern torpedo boats, and modern men-of-war were pitted against one another. The author is indebted to an English officer of high attainments for the following valuable contribution to naval science. The gentleman in question was one of Admiral Ting's most trusted officers, and the interesting details which he gives concerning his experiences clearly shows that he was able to judge the aspects of the fighting from an educated standpoint. His narrative lacks that sensational element which has hitherto figured so largely in the accounts of other witnesses of the engagement, but instead we have a technical and therefore more highly valuable description of it. The account is given in the officer's own words.

"Before describing the torpedoing of the *Ting Yuen*, it will be well to state the routine with regard to the

closing of her W. T. doors and what the condition of these was.

"All doors through which no general traffic occurred were never to be left open. All doors in charge of the engineers—engine rooms, stokeholds, tunnels, and after side passages—were to be shut at evening quarters at 8 p.m. All doors, through which general traffic occurred, were to be closed when 'man and arm ship' was sounded, except those few doors which were necessarily open for the supply of ammunition, these being closed by special bugle call.

"The indiarubber of the ordinary hinged doors had not been renewed for a number of years. In some places it had been painted over. It was not however in a very bad condition, and nowhere was it absolutely rotten or missing. The doors in the engine rooms and stoke holes were wedge doors. These were kept clean and in working order. The store rooms above the armoured deck were closed by water-tight hatches. The rubber of these was in a very bad condition. These hatchways were closed by single screw-bolts in the middle. The double bottom manholes were in excellent order, the replacing of the old gaskets by india-rubber having been completed only a few days before.

"As to the value of my evidence about the condition of these doors, I may say that I personally inspected every one. No care was spared to make them as efficient as the means at our disposal rendered possible. The discipline as regards the closing of the doors was not bad. The doors in charge of the engineers were occasionally inspected after evening quarters. On no occasion had I found any of them open.

"The torpedo attack, which had such disastrous results for us, occurred at about four o'clock in the morning, a short time after the moon had set. Alarm rockets from our guard boats to the south of Itau were seen. Presently firing took

place from some of our ships. We ourselves opened fire, but what the object was I could not distinguish. After a time we ceased firing, and just then I saw a dark object, probably about half a mile away. Fire was opened on it, and I ran up the standard compass erection to get a better view. Through my glasses I saw a double funnelled torpedo boat coming end on for us on our port beam. When she was about 300 yards off she turned hard a port. As she turned I saw that we had hit her badly, as a lot of steam was to be seen. A few seconds after she turned, we were hit on the quarter. The shock was a heavy quivering one, such as I should imagine an earthquake to be like. The sound of the explosion was a loud dull thud. A column of water dashed on board, and there was a faint sickly smell from the explosion.

"Within a few seconds the bugler had sounded 'close water-tight doors' (but this little delay did not affect the ship). After the bugler had sounded I went down below to see the doors properly closed. I found the water bubbling up through a store room hatch. There was then about a foot of water in my cabin which was near this hatch. The ship had already listed slightly. There were other hatches close to, but I did not notice whether they were leaking. After seeing the water-tight doors closed in this part of the ship (abaft the transverse armour), I went to the engine room. There I was shocked to find the port engine room filling quickly. From the engineers I heard that the port engine after moving a portion of a turn had stuck. The wedge doors of the tunnel and side passages were leaking badly, but apparently not nearly enough to account for the rise in water. The door between the two engine rooms also began to leak, as well as that between the engine room and stokehold on the port side. I asked the engineers *whether* the circulating pumps were drawing from the main

drain, and they said 'Yes.' Seeing the engine room filling and knowing that damage existed a considerable distance further aft (say 30 feet), I came to the conclusion that the damage inflicted was very extensive. The possibility of stopping the hole of course occurred to me. We had however no collision mats, nor had we any sails or awnings on board. I thought too, from what I saw, that the damage inflicted was too great to be stopped by such means.

"In the meantime the cable had been slipped, and Admiral Ting had ordered the ship to be taken over to the south side of Itau (in comparatively deep water) to stop the egress of the hostile boats. Shortly after the ship was got under way, I reported to Ting and Commodore Liu that I believed the damage inflicted to be so great that it was very doubtful whether the ship could be kept afloat, and I advised that she should be beached in such a way that, should repairs be found impossible, she would still be able to use her guns in defence of the harbour. This was, after some hesitation, decided upon, the state of the tide (it being high water) making this plan the more favourable. The ship was accordingly beached on the island inside the east boom (about 1,000 yards distant) and was placed in such a manner as to enable her to use her heavy guns to protect the east entrance. Divers were sent down and patches were prepared in readiness to cover the holes, but it was found impossible to do anything, though the divers reported that the hole was only five feet square. In the meantime, in spite of the large centrifugal pumps and water-tight doors, the large compartments of the ship gradually filled up, water-tight doors leaking, bulk heads giving way, till engine rooms and all four stokeholds were flooded. We had hoped that one of the stokeholds might be kept clear, and thus enable us to have steam for the heavy guns, but by about three o'clock in the afternoon the last fire was

extinguished. The use of the ship as a stationary fort was now of course greatly impaired, but the hand gear of the barbettes was connected up.

"As the tide went down, the afterpart of the ship sank in the mud, so that the ship was inclined in a fore and aft direction, and thus rendered it exceedingly difficult to work the guns. (The Japanese fleet kept out of range on this day, and did not give us an opportunity of making a last fight with the poor ship.) By the evening the gun platform was so much inclined that we could not align our sights at an object 1,000 yards off. We stuck to the ship however as our Q. F. guns would be of use in case of a torpedo attack to the north of Itau. The water was now above the main deck aft. There was no fire in the galley, there was no fresh water, no food, and the thermometer showed 27° of frost.

"The Japanese made another torpedo attack during this night (6th February), but, though the gunboats in our immediate neighbourhood opened fire, we saw nothing of the enemy's boats; nor were we able to distinguish with any certainty the explosion of the Japanese torpedoes amid the rattle of gun fire (we were about 3,000 yards from the vessels attacked). A cruiser, a school ship, and a steam launch were destroyed in this second attack. The next morning the *Ting Yuen* had sunk still further in the mud, the water being above the rails of the main deck aft.

"A critical time occurred when the crew mutinied that morning and insisted on being sent on shore or to some other ships and not to be left in a half sunken wreck, with no water, food, or fire, and the thermometer at 3° Fahrenheit. They had armed themselves (while I was absent from the ship for a short time), and had worked themselves up to a dangerous state of excitement. It was with some difficulty that we managed to calm them down by promising to get

Ting's permission to land them at once. Ting had shifted his flag to the *Chen Yuen.*

"In the afternoon, after landing the Q. F. guns, and the greater part of the ammunition, the ship was deserted.

"In order to form an opinion as to what damage was inflicted on the ship and the reason of her filling up, it will be well to state concisely such evidence as I have bearing upon this matter. It should be remembered that in such circumstances as I was in, it was not likely that I should look upon a torpedoing of my vessel from quite the same point of view as an officer witnessing an experiment. Still, with the idea that they might prove of some use, I did soon afterwards make notes of what I observed.

"The divers were sent down about 11 A.M. From their report we learnt that the damage lay between frames 10 and 12, and covered an area of four or five feet square. I mistrusted their report as to the extent of the damage. When the examination was made the water was low—eleven feet—and was at least one foot above our normal water line. With his helmet just under water the diver could feel the top of the damage with his foot. This top of the damage must therefore have been about five feet above the mud, so that the bottom part of it could not have been properly examined. The top of the damage must have been close to the edge of the armoured deck for it (the edge of the deck) lies about three feet below the normal water line.

"The attempt to place a patch was unsuccessful.

"Within a minute of the ship being struck I was down below and in the passage between the ward room and my (the commander's) cabin. At that time the water was bubbling up from the hatch immediately outside the pantry. This hatch, it must be remembered, is part of a store room, the floor of which is the armoured deck. It

is certain therefore that the water got above the armoured deck at once. The ship had already listed a little, and there were several inches of water in my cabin. I did not notice the other hatches in this passage, but had water been coming up in them to any extent I think I should have seen it. These hatches were those whose state I have already explained as being very bad. Within two or three minutes I was in the port engine room. There was already a considerable amount of water under the plates, and, as I stated before, the engine would not work, though it had revolved half a turn, thus pointing to some damage inflicted to the shaft or its bearings. In this engine room the tunnel door was leaking. I did not see this myself, but was told so by the engineer, who said, however, that the leak was not nearly sufficient to account for the rise in the water when the powerful centrifugal pumps were at work. After this I was some time on deck persuading the admiral not to take his ship into deep water, but to beach her before her list became too much. I was probably half an hour on deck. When I went below again I found the water in the port engine room above the plates. In the starboard engine room the tunnel door was leaking, showing that water had got on the starboard side of the midship longitudinal bulkhead.

"Now the longitudinal bulkhead was an entire one and was not pierced by any doors, pipes, &c. It finished at a bulkhead at frame 5. On the port side of this bulkhead no door existed. Now how did the water get to the starboard side of the midship bulkhead? Either the bulkhead at frame 5 or the midship bulkhead must have been damaged. One was about seventeen feet and the other twelve feet from the point where we were struck, and in each case there was more than one intervening bulkhead.

"My own belief is that the ship was so shaken structurally that both bulkheads and water-tight doors were rendered practically useless. If this be so, will it not point to the futility of minute subdivision except in conjunction with greater structural strength—greater strength, at all events than obtained in this ship.

"Above the armoured deck amidships were two chain lockers. They were separated from one another by a bulkhead, and two other bulkheads existed between each and the ship's side. The hatch of the port locker was forced up within half an hour of our being struck. The ordinary hinged water-tight doors I have spoken of before as being in bad condition. Most of them leaked considerably. I saw one or two cases of ordinary wooden doors with the water on the opening side which kept wonderfully tight, much more so than the average water-tight door. This was owing to the spring in the door allowing the pressure of the water to force it quite home. I cannot help thinking that the pressure of water ought to be made use of in conjunction with a non-rigid door.

"The torpedo boat which sunk us was found floating about the harbour at daylight. She had been hit six times, twice in the boiler room, twice through the funnel, once through the nose of the midship torpedo tube, and once through the bow. These hits were from 3-pounder and 6-pounder guns. There were besides many marks of rifle bullets, but no penetrations. One of the shots had hit the steam-pipe in the boiler room, and evidently scalded all the men there to death. Three bodies were in the stokehold, and another—that of an engineer officer—on deck, but also scalded. On deck there was some (but not much) evidence in the form of blood of men having been hit. We heard afterwards, but I know not with what amount of truth, that the remainder of this boat's crew

were frozen to death. Of the other shots the one through the bow wrecked the fore cabin.

"By rather a curious coincidence, the Chinese officer who was with me when I was examining the boat found three articles which had been looted from his house at Port Arthur—a pair of dumb-bells, a scroll, and a chair. The boat was scrupulously clean in the cabins, and the wrecked fore cabin was a heterogeneous mass of such things as guncotton and detonators, snow-white linen, bottles of sweets, and cigarettes.

"There is a point in connection with the control of fire which I think is worth notice. From the beginning of the time when torpedo attacks became likely, and when we became subject to alarms, real and false, the difficulty of controlling the fire became evident—not from any disciplinary fault, but from the point of view of expediency. Who was to control the fire? The commander could not; no one man could, because he could never be sure of seeing the enemy first. Was then fire to be controlled by many officers scattered over the ship? This in practice, when you think of the excitement of an attack, means no control at all. It means that once an attack is imminent—when the alarm signals have been made and the enemy's boats are in the neighbourhood—that each man will fire at anything suspicious he sees.

"This is what it came to with us; nor did I try to remedy this state of affairs, thinking that a cure might cause worse evils than those which already existed. While however it was tacitly allowed that individual men should open fire at their own discretion, the 'cease fire' bugle-call was rigidly enforced. For instance, on the *Ting Yuen*, when 'man and arm ship' was sounded I was down below. When I came on deck we had opened fire, but I could see no object. From the position from where the alarm rockets had been

fired I knew that if the enemy were attacking they had got in south of Itau, and would from the way we were swung probably attack our port side. I therefore risked giving the 'cease fire.' Almost immediately the smoke had cleared away, I saw the Japanese coming up about half a mile away. Fire was again opened without order (the men seeing her as soon as I did), and about a minute afterwards we destroyed one another. I think, however, had it not been for that 'cease fire' she would have got away scot free. This is a case where, had fire been held till ordered by me, no evil would have resulted, as I happened to see the boat as soon as any one; but one could never make certain of being the first, even when the probable direction of attack is known. The evil, however, of this independent firing is obvious. Once smoke is floating about it is the easiest possible thing to imagine one sees objects. False alarms were occasionally caused by our own patrol boats, which were more than once fired upon. This however was invariably their fault for being slack in showing their signal lights.

"I thought it not unlikely that the Japanese would attack us under cover of our own distinguishing lights. This however they did not do; but the question of distinguishing lights seems to me to be an important and difficult one. Our method was for the ship to show a certain light, and the boat to answer with a combination of two. These colours were changed daily, and made known only in the evening. It was however a system which the enemy might possibly have discovered by observation. We tried therefore a development of it: the ship to show one or the other of two lights, and the boat to answer with a combination of two corresponding to the light shown. It proved however too cumbersome for us, and we reverted to the first plan.

"I mentioned before that the night after the *Ting Yuen* was sunk the Japanese made another torpedo attack and sank two of our vessels besides a steam launch. The *Lai Yuen*, a German-built cruiser, was at anchor and capsized within five minutes of being struck, a large number, about a hundred, I believe, of her crew being drowned. The *Wei Yuen*, an old wooden corvette used as a gunnery school, was alongside the wharf when she was struck. A third torpedo evidently struck the bottom in about 9 feet of water underneath a large steam launch. This launch was lying outside a lighter covered with ammunition from the *Ting Yuen*, and which was itself alongside the wharf. The result of the explosion was to blow a large portion of the launch on to the wharf, together with a considerable portion of the bottom sand and stones. The lighter was not sunk, but the ammunition on its deck was jerked partly on to the wharf and partly over. The torpedo which did this was probably one that missed the *Wei Yuen*; at least one torpedo was picked up on the beach after this attack.

"I will now add a few notes as they occur to me.

"The effect of the torpedo explosion was not very severe to the person. I saw no one thrown down on deck, but it was severe enough to make that possible. One Chinese officer was asleep in his bunk at the time. This was about 25 feet further forward and on the same side as the hit. He was thrown out of his bunk and bruised, but not damaged otherwise. No heavy weights were displaced, but furniture (such as chests of drawers) were thrown about. On deck the only damage visible was the tearing away of the moulding on the ship's side in the vicinity of the hit.

"The effect of the shock was not demoralising. There was no panic, the men going to their stations as ordered in the usual manner.

"I do not think there was any great strain on the nerves from anxiety due to impending attacks. It never prevented any one sleeping well so far as I know. Such strain as there was could not be compared to that experienced in five hours' sharp fighting as in the Yalu.

"An incident occurred in the Yalu battle in connection with torpedo boats. The *Fulung*, one of the two first-class boats possessed by the Chinese, approached the Japanese *Saikio* bow on and fired two torpedoes in the bow tubes. Both of these missed, or, as Choy, the officer in charge, said the *Saikio* dodged them. After this there was nothing for the boat to do except pass close alongside. Choy assured me that he passed within 40 feet of her, and that the Japanese were panic-stricken and left their guns. The broadside torpedo was fired point blank, but it evidently dived and went under the enemy. The *Fulung* was not hit at all.

"Two Americans came to Weiheiwei with a scheme for destroying the Japanese fleet. Whatever may be thought as to the impossibility of their method, I personally have my doubt of the honesty of their convictions. They were to be paid only by results. They risked the imputation of having broken their patrole. One of them, Howie, was an ex-American naval officer. He had been employed on the Howell torpedo and had fought in one of the South American wars. He impressed me as an eminently practical man, not as a hare-brained schemist. Yet their idea was of so large an order that faith in it was an impossibility. They proposed to be able to do the following—by means of a vessel fitted up something after the manner of a watering cart the surface of the sea was to be covered with a film of some chemical which I gathered to be naphtha or something analogous. A shell containing

some special chemical (the principal part of this invention) was then to be fired into the field, with the result that the whole field would detonate and destroy everything within its area. A gunboat was specially fitted according to their directions, but the chemicals were treacherously destroyed in Chefoo where they were in junks, waiting for an opportunity to run to Weiheiwei."

If any reader of this book had any doubt in his mind before he reached this chapter of the real power of torpedoes, he can possess it no longer. In this plain, unvarnished description of the action off Weiheiwei we have overwhelming proof of the power of a torpedo to accomplish in one second what all the guns of the Japanese fleet failed to bring about in five hours.

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